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Guide to implementation of phytosanitary standards in forestry

Second edition

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Foreword

With their rich biodiversity and vital ecological roles, forests are a cornerstone of sustainable development and environmental conservation. In a dynamic and changing world, however, we continue to be confronted with new challenges that threaten the health of our forests and the forest sector. Climate change, coupled with expanding global trade and travel, has enabled the rapid introduction and spread of damaging non-native pests within and between countries.

Therefore, it has never been more imperative to implement robust phytosanitary practices in the forest sector to reduce the risk to our forests from pests. The International Plant Protection Convention (IPPC) plays a crucial role in safeguarding global agriculture, trade and ecosystems by promoting plant health, preventing the spread of pests, and facilitating safe trade. One of the ways it does this is through International Standards for Phytosanitary Measures (ISPMs).

The first edition of this guide was published in 2011 to provide the forest sector with clear, concise guidance on forest health practices, including plain-language descriptions of the ISPMs and suggestions for improving their implementation. The guide has been frequently requested and reprinted in response to the needs of FAO Members. It has been translated into eight languages, and it has formed the basis of many training materials, customized for specific regional needs.

Many updates to the ISPMs have been made since 2011, including the adoption of 13 new standards, many of which are directly relevant to forests and the forest sector. To ensure the guide's continued relevance and effectiveness, FAO initiated a review in 2021 with a new core group of specialists and peer reviewers. The present updated version of the guide is the result of this review. We trust that it will prove just as valuable as the first edition by providing forest policymakers, planners, managers and workers with the knowledge and guidance they need to reduce the risk of pest spread in international trade and thereby help protect forests and the livelihoods of forest-dependent people.

Zhimin Wu

Director, FAO Forestry Division

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THE PRESENT EDITION

FAO produced this updated edition of *Guide to Implementation of Phytosanitary standards in Forestry* in collaboration with an international group of scientists, phytosanitary specialists and forest-sector representatives. FAO extends its sincere thanks to all the group's members and their organizations for their dedication and time.

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THE FIRST EDITION

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Abbreviations

CPM	Commission on Phytosanitary Measures
DNA/RNA	deoxyribonucleic acid/ribonucleic acid
EUR	euro(s)
FAO	Food and Agriculture Organization of the United Nations
IPM	integrated pest management
IPPC	International Plant Protection Convention
ISPM	International Standard for Phytosanitary Measures
NPPO	national plant protection organization
PFA	pest-free area
PFPP	pest-free place of production
PRA	pest risk analysis
RPPO	regional plant protection organization
USD	United States dollar(s)
VME	vehicles, machinery and equipment
WPM	wood packaging material
WTO	World Trade Organization

Units of measurements

cm	centimetre(s)
ha	hectare(s)
m	metre(s)
mm	millimetre(s)

Summary

This publication is a comprehensive guide for forestry professionals, policymakers and stakeholders in understanding and applying phytosanitary standards in the forest sector. Phytosanitary measures are crucial for safeguarding forests against the introduction and spread of harmful pests and diseases (collectively called pests), ensuring the sustainable management of forest resources, and protecting global biodiversity. Originally published in 2011, this updated edition describes a wide range of phytosanitary concepts and recommended practices in the forest sector.

Introduction. The guide begins with discussion of the threats posed by pests to the world's forests. It introduces the International Plant Protection Convention (IPPC) and International Standards for Phytosanitary Measures (ISPMs) and discusses how the latter can be implemented in the forest sector to reduce the damaging impacts of forest pests.

Trade in forest commodities. The variety of forest commodities and their pest risks and risk management options are presented. This chapter explains how ISPMs and national plant protection organization (NPPO) regulations affect imports and exports of forest commodities and illustrates the steps involved in safely importing and exporting forest commodities.

Good practices for forest health protection. The most efficient way to reduce the risk of spreading pests in trade is to implement good practices throughout the supply chains of forest commodities. This chapter provides information on integrated pest management practices for all phases of, and sites involved in, forest resource management, including forest operations, forest nurseries, planted and naturally regenerated forests, post-harvest treatments and sawmills, and product transportation, distribution and storage. Challenges posed by woodfuels, plants for planting, intentionally introduced tree species and seed movement are highlighted.

Phytosanitary concepts simplified. This chapter describes the IPPC and how ISPMs are developed and adopted. ISPMs support good forest practices and safer trade in forest commodities and other traded commodities that use wood packaging material. The guidance contained in the most relevant ISPMs to forestry, such as pest risk analysis, wood packaging material, and systems approaches, is discussed and practical examples provided.

The way forward. This chapter summarizes the importance of implementing phytosanitary standards in the forest sector and discusses the continuing work in this area. Forest-sector personnel can work with NPPOs to develop and implement ISPMs and national phytosanitary regulations that help reduce pest movement.

Annexes provide examples of forest pest introductions and their impacts around the world, a glossary of relevant terms, and a full list of adopted ISPMs to date.

This updated guide should prove valuable to all stakeholders in forestry and related trade, including forest policymakers, planners, managers and educators. By incorporating the recommendations and practices it outlines, stakeholders can strengthen the resilience of forest ecosystems, protect biodiversity, and ensure the sustainable development of the forest sector while effectively managing the risks posed by pests.

1 Introduction

Forests are important resources that provide a wide range of economic, social and environmental benefits. The world has 4.06 billion hectares (ha) of forest, which is 31 percent of the total land area (FAO, 2020). Forests produce diverse valuable products, such as timber, woodfuel, fibre and other wood and non-wood forest products, and contribute to the livelihoods of many rural communities. They also provide vital ecosystem services – for example, they help combat desertification, protect watersheds, regulate climate and conserve biodiversity. Forests play important roles in maintaining sociocultural values and people's physical and mental health.

Forests can support climate-change mitigation and adaptation. They absorb carbon from the atmosphere and store it in biomass, soils and forest products. Well-managed forests can produce sustainable supplies of woodfuel, a renewable alternative to fossil fuels. Conserving forests, replanting harvested forests and managing forests to ensure their health and productivity are all important ways to reduce the concentration of carbon dioxide in the atmosphere and maintain the host of biodiversity benefits and other ecosystem services that help people and ecosystems adapt to climate change (Libert-Amico *et al.*, 2022).

1.1 PEST THREATS TO THE WORLD'S FORESTS

It is important, therefore, to protect the world's forests from harm. The health and vitality of forest ecosystems are affected by disturbance agents such as pests,[1] drought and fire, which are fuelled by climate change. Although disturbance is a natural part of succession processes in forests, major disturbance events can limit the ability to meet forest management objectives. Insects, diseases and severe weather events damaged about 40 million ha of forests in 2015, mainly in the temperate and boreal domains (FAO, 2020). The average annual forest area affected by insects in 2000–2016 was 29.1 million ha (in 44 countries representing 47 percent of the world's forest area) (FAO, 2020). The average forest area affected by disease in reporting countries in 2002–2017 was 4.76 million ha (33 countries representing 37 percent of the world's forest area) (FAO, 2020).

Pest species – both native and non-native[2] – can be significant problems in forests and forestry, particularly when populations reach "outbreak" proportions.

---

[1] Any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products (ISPM No. 5 – IPPC Secretariat, 2023a).

[2] Native species (also called indigenous species) are those occurring within the range they occupy naturally or could occupy, without direct or indirect introduction by humans. Non-native species (also called non-indigenous or introduced species) are those occurring in an area outside their historically known natural range because of intentional or accidental dispersal by human activities.

Non-native pests, introduced accidentally through trade or other means, may be especially damaging. Because they didn't evolve as components of the forests to which they are introduced, they may lack natural enemies that would otherwise keep populations in balance, and host plants may have insufficient or no resistance. Climate change may aid the establishment of pests in new locations and increase the severity of the impacts of both native and non-native pests. Annex 1 provides examples of major pest introductions and their impacts on forests.

1.2 PROTECTING THE WORLD'S FORESTS

The successful protection of the world's plants – including forest tree species – from pests requires coordinated international action, such as that provided by the International Plant Protection Convention (IPPC), which is an international agreement between countries that aims to protect plants by preventing the introduction and spread of pests. The IPPC's governing body is the Commission on Phytosanitary Measures (CPM), which adopts International Standards for Phytosanitary Measures (ISPMs)[3] to prevent pest introduction and spread and to facilitate trade. The CPM also reviews the state of plant protection around the world and identifies actions to control the spread of pests to new areas.[4]

As of January 2024, 184 countries were contracting parties to the Convention. Each contracting party has a designated national plant protection organization (NPPO) to protect natural resources, including forests, from pest entry and establishment.[5] NPPOs frequently work with neighbouring countries to prevent pest entry and spread between countries, often through regional plant protection organizations (RPPOs). NPPOs designate official contact points to the IPPC, and NPPOs work as a group to develop ISPMs.

All member countries agree that ISPMs are effective in managing pest risks and enabling safer trade, and NPPOs use them as the basis of national phytosanitary regulations. It is important for all actors involved in the forest products trade to be aware of and understand ISPMs and their potential impacts on trade. ISPMs developed by the IPPC are recognized by the World Trade Organization (WTO), which provides a dispute-resolution process for trade issues.

The IPPC Secretariat, hosted by FAO, facilitates the work programme of the CPM and enables close collaboration with related international organizations and conventions.

---

[3] Annex 3 gives the titles of all existing ISPMs and a short description of each. Note that the year in which the ISPM was originally created is given alongside its number (e.g. ISPM No. 2, 2007). In this document, the latest version of the ISPM is cited by its publication year (e.g. IPPC Secretariat, 2016a).

[4] More information on the organization and work of the IPPC is available at www.ippc.int.

[5] Countries may have specific names for their NPPOs, such as plant health inspectorate or quarantine service. The full list of NPPOs and their official contact persons is available at www.ippc.int.

1.3 ABOUT THIS GUIDE

This guide is designed to help reduce the human-facilitated spread of forest pests and their impacts. It provides easy-to-understand information on ISPMs and the role of forest management practices in implementing phytosanitary standards and facilitating safe trade. Specifically, it addresses how:

- ISPMs and NPPO regulations can affect imports and exports of forest commodities, comprising wood and non-wood forest products (Chapter 2);
- people in the forest sector can reduce the risk of spreading pests through effective management approaches (Chapter 3);
- ISPMs can be used to minimize the risk of forest pest introduction and spread (Chapter 4); and
- forest-sector personnel can work with NPPOs to develop and implement ISPMs and national phytosanitary regulations that help reduce pest movement while restricting trade to the least-possible extent (Chapter 5).

Annex 1 provides examples of forest pest introductions and their impacts, Annex 2 comprises a glossary of the terminology used, and Annex 3 contains a list of all adopted ISPMs and brief descriptions of each.

This guide should prove valuable to all forest-sector actors, such as policymakers, planners, managers and educators.

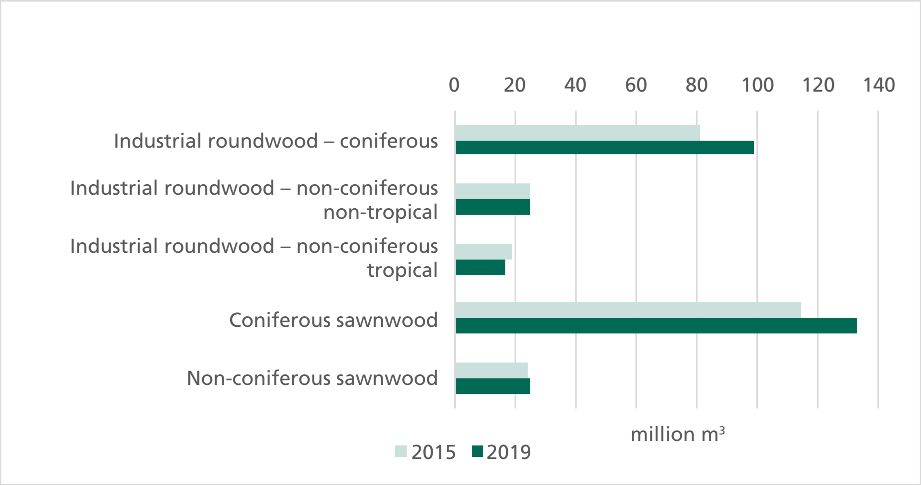
2 Trade in forest commodities

Forest commodities are wood and non-wood products produced from plants and trees grown in forests or on other wooded lands. In volume (and value) terms, wood products comprise the most significant type of forest commodity. The volume of many categories of wood products in international trade increased between 2015 and 2019 (FAO, 2021) (Figure 1 shows this for some product categories).

Most countries involved in the international trade of forest commodities recognize the importance of protecting plants, including forest plants and trees, from pests. NPPOs are tasked with implementing ISPMs as part of national phytosanitary regulations for imported forest commodities. Where required, NPPOs also certify that export consignments meet the phytosanitary import requirements of other countries.

FIGURE 1

Change in global exports of roundwood and sawnwood, 2015–2019



Source: FAO. 2021. FAO Yearbook of F*orest Products 2019*. Rome. https://doi.org/10.4060/cb3795m

Import requirements may differ between countries for the same commodity. Usually, these differences are the result of variations in the assessments by countries of the pest risks associated with a given commodity, which may be due to differences in the susceptibility of forests to pests or in the level of pest risk a country is prepared to accept (Box 1 provides an example for logs/roundwood[6]).

---

[6] The terms “logs” and “roundwood” are used interchangeably in this publication.

ISPMs continue to be developed and revised to assist in the international trade of forest commodities and to reduce pest spread.

This chapter outlines how ISPMs and NPPO regulations affect the trade of forest commodities.

BOX 1 Logs/roundwood – an example of the relationship between pest risk and phytosanitary import requirements

Logs may contain many kinds of organisms, and not all logs pose the same level of risk for the movement, establishment and spread of forest pests. Countries may vary in their assessments of the risks associated with log imports, depending on their origin, species, log size and presence or absence of bark and whether pests of concern are present and widely distributed in the country in question. Some countries lack phytosanitary import requirements for logs, and some require phytosanitary certification based only on visual inspection for pests. Other countries may require or accept a particular treatment and in some cases certification that such treatment was undertaken before export. Such phytosanitary import requirements are established based on the assessed risk of pests moving on or in the logs. For example, logs imported into Canada from a tropical country might contain pests that are geographically constrained – that is, restricted to tropical climates and trees. Canada has no tropical forests and therefore few phytosanitary import requirements for tropical species. If logs might contain pests with the potential to establish and cause damage to important plants in an importing country, that country's national plant protection organization may prescribe specific phytosanitary measures to manage this risk.

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The phytosanitary risks associated with log imports depend on a range of factors, such as the log's origin, species and size, the presence or absence of bark, and whether pests of concern are present and widely distributed in the country in question

2.1 FOREST COMMODITIES

Box 2 presents the main categories of forest commodities, their pest risks and risk management strategies.

BOX 2 Forest commodities, their pest risks, and risk management options

The forest commodities described below are arranged in order of decreasing pest risk.

Plants for planting, excluding seeds

Plants for planting (i.e. nursery stock, including bonsai and rooted trees) are increasingly recognized as carriers of pests, which could be associated with stems (wood and bark), branches, foliage, fruit/cones, roots and sometimes soil and growing media. Bonsai plants, potted Christmas trees and large trees for planting present higher risks because they comprise most of these components. Various pests (in a range of life stages) may move with plants for planting, such as aphids; scale insects; adelgids; bark beetles; wood borers; weevils and moths; wasps; mites; nematodes; foliar, cone, root-rot and canker fungi; oomycetes; bacteria; viruses; viroids; and phytoplasmas.

Plants for planting might be planted outdoors near other host plants, thereby increasing the risk of pest introduction and spread.

Importing countries generally conduct pest risk analyses (see section 4.2) to identify pests of concern and ways to reduce risk. Potential pest management measures include surveillance, pest-specific surveys, identification of pest-free areas, treatment, pre-shipment inspections, post-entry quarantine, and prohibition. Additional opportunities to inspect for pests might occur during the handling of plants for planting (including pruning, harvesting and packaging) by appropriately trained personnel.

Cut branches

Cut branches, including Christmas trees without roots, may carry many of the same pests as plants for planting except for pests of roots, soils and substrates. The risk of pest transmission to living host trees is lower, however, because cut branches are most-often used indoors, reducing their pest risk in natural environments. Nevertheless, cut branches may still contain insects that are strong fliers, or fungal spores, which, when the branches are discarded, could spread by air currents and rain splash.

Christmas trees are a widely used commodity and are often grown in monocultures, which increases the potential for pest outbreaks and spread. Christmas trees are often moved during a limited portion of the year, however, and, if properly discarded, may not pose a risk for pest movement.

Potential pest management measures include pest surveys, limiting harvesting to pest-free areas, treatment, pre-shipment inspections, safeguarded disposal after use, and prohibition.

Logs/roundwood (e.g. poles, posts, timber, pilings)

Logs with bark are considered higher-risk than logs that are debarked or bark-free.* Both barked and bark-free logs can carry pests, but debarked logs are less likely to have pests that colonize bark or the portion of wood immediately below the bark. Managing the insect pests living in or just under the bark of logs generally involves bark removal, heat treatment or fumigation. For deep-wood-boring insects, heat treatment and fumigation are the primary management measures; in some cases, irradiation may also be used. For fungal pathogens, fumigation, heat treatment and end-use processing can reduce pest risk. Visual inspection during post-harvest grading can help remove infected logs and portions of infected logs, although in some cases this measure is insufficient to identify early stages of decay.

Fumigants only penetrate a portion of the outer surfaces of logs and are considered less effective on logs with bark, particularly wet bark.

Sawnwood (e.g. boards, lumber, timber, squared wood)

Sawnwood has lower pest risk than roundwood because sawing removes most of the bark as well as some of the outer wood, thus eliminating most wood pests living in or just under the bark.

The risk management measures suggested above for roundwood are equally effective for sawnwood. The risk of infestation by blue-stain fungi and some wilt organisms can be managed by reducing the moisture content of the wood through kiln- or air-drying.

Wood chips

The pest risk of wood chips depends on the size and moisture content of the chips, the presence of bark and other debris, and especially how the chips are handled, transported, stored and used. Wood chips used as landscape materials can spread small insects, nematodes and fungi. Any pests present in wood chips used for pulp production and energy generation will be killed by processing.

For most insect pests, the smaller the wood chips, the lower the risk of infestation, but processing into wood chips may not reduce the risk of pathogens. Pest risk can be managed by heat treatment, reducing moisture content, fumigation, and safeguarding the wood chips from infestation and contamination during transport, handling and storage.

Fuelwood

Fuelwood is often produced from low-quality wood and from trees infested with pests (e.g. bark beetles, deep-wood-boring insects, nematodes and fungi). Consequently, the transportation of fuelwood, both domestically and internationally, often spreads pests.

The in-country transport of fuelwood, which is frequently unregulated, can be an efficient pathway for the spread of introduced species that are established in more localized areas.

Heat treatment, fumigation and proper safeguarding during transport and storage can reduce pest risk in fuelwood.

Bark

Bark can carry various pests (e.g. insects, fungi and nematodes). Pest risk depends largely on the intended use – bark can be used as fuel, landscape mulch and a growing medium and to produce processed wood products. Infested bark used as mulch or growing media presents the highest risk. Measures to manage pest risk for bark include heat treatment, irradiation, reducing moisture content, fumigation, composting, safeguarding during transport and storage, and prohibition.

Wood packaging material

Wood packaging is sometimes made from low-quality wood that may contain pests, either in the wood or associated with bark remnants. It is recognized internationally as high-risk, and wood packaging material must therefore be made from debarked wood (with a specified tolerance) that is heat-treated or fumigated and marked with a specific, internationally accepted mark (see section 4.3).

Wood-based panels

Wood-based panels such as veneer sheets, plywood, particleboard (including oriented strandboard) and fibreboard (including medium-density fibreboard) are assembled using heat, pressure and glue and are generally free of primary wood pests. Importers and other users should check with the relevant national plant protection organizations to see if newer processes that use lower temperatures and environmentally friendly glues (as well as pressure) are acceptable as a phytosanitary treatment.

Termites and dry-wood borers can infest almost any wood products after manufacture, even if heated. Inspection can be used to detect infestations.

Manufactured wood products

Manufactured wood products such as handicrafts and furniture are diverse, and their pest risk is dependent on wood origin and species, the degree of processing, and the intended use. If the processing method is unlikely to kill pests, further treatment, such as heat, fumigation or irradiation, may be needed.

Forest seeds

Seeds can carry pests either on their surfaces or internally. The degree of pest risk depends on the pest type (e.g. fungal or insect), seed origin, the reliability of pest detection, the intended use, and storage conditions at the place of end use. Another factor in determining pest risk is whether the seed can survive drying and freezing in storage (i.e. "orthodox" seeds) or cannot survive such conditions ("recalcitrant" seeds). Pests of recalcitrant seeds may have a better chance of survival during storage because they will not be subjected to the dry, freezing conditions in which orthodox seeds can be stored.

Measures to manage pest risk for forest seeds include monitoring at the place of origin, recognition of pest-free areas, and seed testing for pest detection. If an infestation of seeds is detected, appropriate measures such as destruction and treatment with heat, chemicals or irradiation may be needed or the export should not be carried out (see section 3.12 and section 4.13).

Tissue-culture plants

Tissue culture is generally considered the safest way to move plant propagative material. However, even these tiny plants are not completely sterile – some have been shown to carry latent or dormant fungi, bacteria, viruses, viroids and phytoplasmas.

* Bark-free wood is wood from which all bark, except ingrown bark around knots and bark pockets between rings of annual growth, has been removed. Debarked wood is wood that has been subjected to any process that results in the removal of bark. Debarked wood is not necessarily bark-free wood (ISPM No. 5, 2021 – IPPC Secretariat, 2023a).

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High-pest-risk commodities such as nursery stock often need to be accompanied by phytosanitary certificates

ISPMs and national regulations apply to any items that may be infested or contaminated by pests and to any organism that can serve as a vector or could itself be a potential pest. Regulated articles may include equipment used to process or transport the infested or contaminated items, such as logging trucks, wood-handling equipment, shipping containers, barges, ships, railway cars, wood packaging material (WPM) and other storage units used to move forest commodities (see section 3.7 and section 3.13).

2.2 IMPORTS OF FOREST COMMODITIES

Contracting parties – that is, countries that are signatories to the IPPC – have the sovereign right to make regulations to protect their resources, including forests, from the introduction and establishment of pests. For pests of concern, each country's NPPO may establish regulations that specify their phytosanitary import requirements for commodities through the use of an evaluation process called pest risk analysis (PRA, see section 4.3). Forest-sector personnel can play an important role in assisting the NPPO to determine pest status and keep regulations up to date and effective by sharing pest information, supporting survey activities for pests, and providing information about new pests.

NPPOs of importing countries establish phytosanitary import requirements based on an evaluation process that carefully considers all aspects of a pest's risk, including:

- its biology and association with the commodity;
- its potential to be moved in association with the trade of commodities;
- its potential to enter, establish and spread in the importing country; and
- its potential to cause economic or environmental harm if it becomes established and the resulting consequences.

PRAs involve an evaluation of the existing scientific evidence and technical information and may take several years to complete. Simple PRAs may be carried out that take less time and fewer resources but may still provide a good understanding of the risks and enable trade with the application of appropriate pest management measures.

Once a PRA is complete, the importing country may establish regulations and appropriate phytosanitary import requirements to manage the risk or prohibit the import of a consignment from a specified origin. Import requirements are decided by the importing country's NPPO but can often be negotiated bilaterally between the NPPOs of the importing and exporting countries. Import requirements may include activities to be carried out in the exporting country, in transit, and on entry to the importing country (Box 3).

Industries must comply with import and export requirements; those wishing to import forest commodities should contact their NPPO as a first step.

Imported consignments of forest commodities, especially those considered high-risk (e.g. nursery stock, seeds, untreated roundwood with bark, and Christmas trees), are often required to be accompanied by a phytosanitary certificate issued by the NPPO of the exporting country (see section 4.10). A phytosanitary certificate is a document certifying the health of plants, plant products and commodities or confirming that treatment has been carried out. It is a written statement that the consignment is compliant with the importing country's requirements; it certifies that any measures required to be taken before export have been completed satisfactorily or that appropriate provision has been made for measures to be applied during transport.

BOX 3 Examples of phytosanitary measures that may be applied to forest commodities

Prior to export

- Assurance that the commodity originates from an area or a place of production that is free of specified pests
- Commodity production based on specific requirements (e.g. debarking)
- Inspection during the growing season and before shipment
- Appropriate treatment and post-harvest handling
- Safeguarding treatments during storage (e.g. chemical sprays)
- Prohibition of imports

During transport

- Phytosanitary treatments (e.g. fumigation)
- Safeguarding (covering or enclosing the commodity in containment)
- Transport within a specified period (e.g. Christmas trees may only be shipped during pest dormancy)
- Restrictions on transport through, or storage in, pest-free areas

After arrival in the importing country

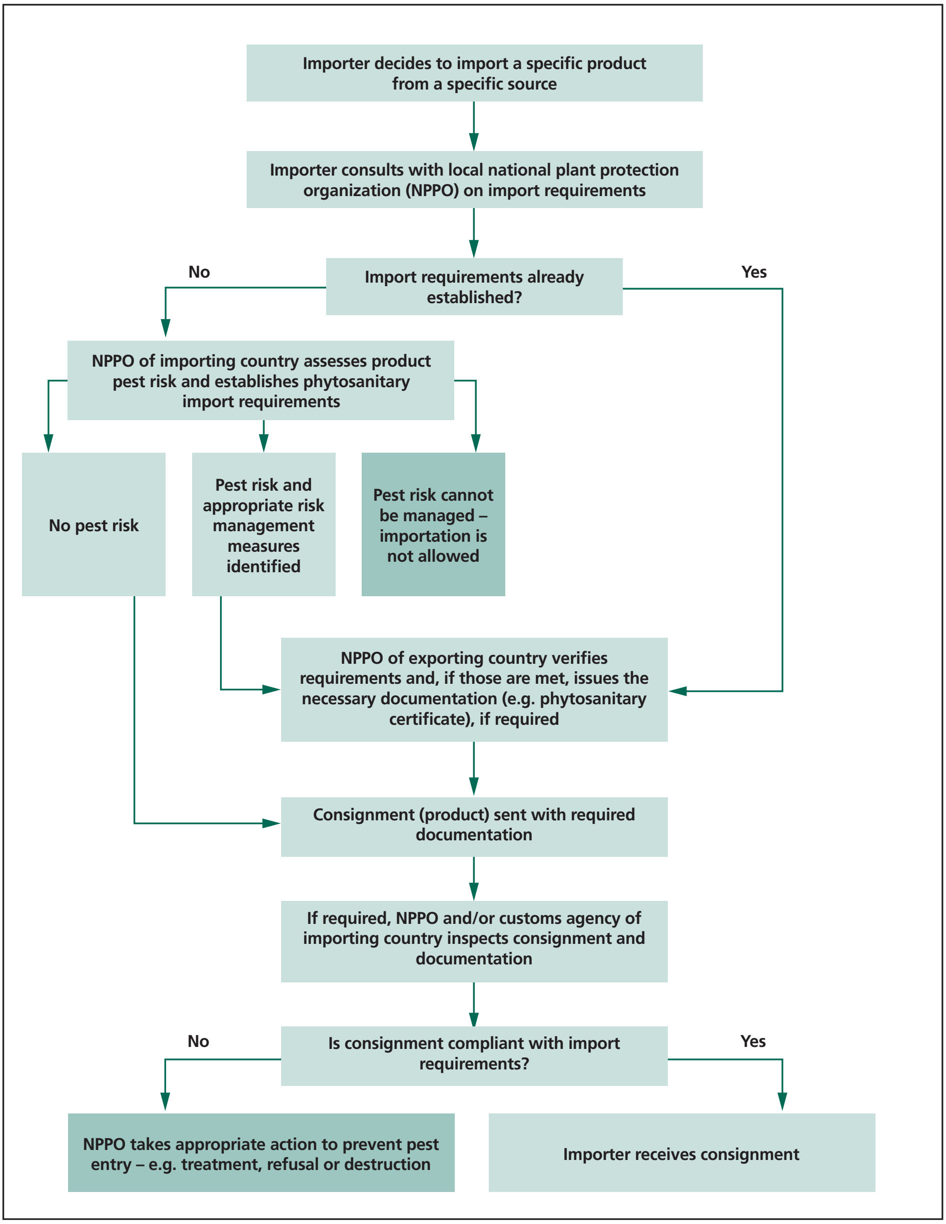
- Inspection
- Specific processing (e.g. debarking and processing the bark; sawing; pellet production; steam heating during veneer production)
- Entry and use within a specified period or season
- Post-entry treatment
- Post-entry quarantine

This is not an exhaustive list. Moreover, many of these measures may be used singly or in combination to manage single pests or groups of pests.

Commodities that fail to meet phytosanitary import requirements may be treated at the point of entry, rejected from entry to the importing country, destroyed, redirected to another country that will accept them, or returned to the exporting country. When consignments are rejected because they fail to meet import requirements, the NPPO should notify the exporting country so that corrective actions can be taken to avoid repeat rejections (see section 4.11). The rejection of a consignment may impose significant costs on both importer and exporter.

Most countries make special arrangements to permit the entry of normally prohibited articles, such as for academic or industrial testing, breeding purposes, or certain industrial applications. These arrangements are usually developed on a case-by-case basis and are determined by the NPPO of the importing country. Usually, the NPPO of the importing country provides a special permit (import permit) or letter to authorize this type of limited import. Figure 2 shows the steps that may be followed to import or export forest commodities.

FIGURE 2
Steps in the import/export process for forest products


Importer decides to import a specific product from a specific source
Importer consults with local national plant protection organization (NPPO) on import requirements
No
Import requirements already established?
Yes
NPPO of importing country assesses product pest risk and establishes phytosanitary import requirements
No pest risk
Pest risk and appropriate risk management measures identified
Pest risk cannot be managed – importation is not allowed
NPPO of exporting country verifies requirements and, if those are met, issues the necessary documentation (e.g. phytosanitary certificate), if required
Consignment (product) sent with required documentation
If required, NPPO and/or customs agency of importing country inspects consignment and documentation
No
Is consignment compliant with import requirements?
Yes
NPPO takes appropriate action to prevent pest entry – e.g. treatment, refusal or destruction
Importer receives consignment

2.3 EXPORT OF FOREST COMMODITIES

To export forest commodities, the exporter should first contact its NPPO. NPPOs have cooperative relationships with the NPPOs of trading-partner countries. Ideally, the exporting country's NPPO should have information on the phytosanitary import requirements of different countries and the steps that need to be followed to export goods. The exporter may also obtain details about requirements directly from the importing country's NPPO or through the importer, who can obtain the requirements from its NPPO. Exporters should be aware that different countries may have different requirements for a commodity, even if those countries appear to be geographically related. It is in the best interests of exporters to ensure that commodities comply with requirements before export.

If the importing country has not developed specific phytosanitary import requirements for a particular commodity, there may be a need to initiate a PRA (as shown in Figure 2). For a PRA, the NPPO of the importing country may request information and technical data on potential pests associated with the commodity from the NPPO of the exporting country and may even request a description of potential measures that could be applied to manage the risk of pest movement.

Often, the NPPO of the exporting country has additional information on the pests associated with the commodity and can share this with the importing country's NPPO. This cooperative process between NPPOs can aid the development of bilateral arrangements to establish import requirements for a commodity from a specific region. Such arrangements may also provide a mechanism for deciding whether to permit the importation of normally prohibited or regulated items for scientific or industrial testing with specified phytosanitary measures. A phytosanitary certificate is required for many imported forest commodities, which must be issued by the NPPO of the exporting country. The NPPO of the exporting country arranges with the exporter to verify that the import requirements (e.g. treatments and production practices) have been met and to conduct any required inspections.

The NPPO of the exporting country may conduct inspections or delegate these to an authorized entity[7] (an organization or individual) under the NPPO's control and responsibility. Some activities required to support phytosanitary certificates, such as periodic inspections during the production cycle and integrated pest management (IPM) activities, may be carried out most effectively by foresters, under the authority of the NPPO, during the handling and processing of harvested wood (see Chapter 3). In some cases, where commodities move from one country to a second country and then to a third country, the NPPO in the second country might need to issue a re-export phytosanitary certificate to meet the requirements of the final destination country (see section 4.10).

Under some bilateral agreements, other certificates, such as treatment certificates and manufacturer's declarations, may be used as an alternative – or in addition – to phytosanitary certificates. Often, such certificates contain only a portion of the information required on a phytosanitary certificate, such as when, where and how a specific treatment was applied.

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[7] See IPPC Secretariat. 2021. *Requirements for national plant protection organizations if authorizing entities to perform phytosanitary actions*. International Standard for Phytosanitary Measures No. 45. Rome, FAO on behalf of the Secretariat of the International Plant Protection Convention.

The NPPOs of some countries require import permits that specify their phytosanitary import requirements and authorize the importation of a given commodity. Usually, the importer is responsible for obtaining the import permit and for providing the details to the NPPO of the exporting country, through the exporter.

Certain processed forest commodities (e.g. plywood and fibreboard) are recognized as posing a lower pest risk and so may be exempt from certain requirements. NPPOs may require certification of the kind of processing completed for the product to ensure it qualifies for an exemption. General guidance is available on the types of forest commodities that might not require phytosanitary certificates as a result of processing and the intended use.[8]

In addition to the phytosanitary regulations of an importing country, there may be other requirements, such as those arising from the Convention on International Trade in Endangered Species of Wild Fauna and Flora, the Convention on Biological Diversity and other international agreements. In some cases, these separate requirements may be administered by an authority other than the NPPO. Some exporting countries may also require permits for the export of viable materials, such as those with potential to provide useful medicinal drugs.

In addition to the forest products themselves, equipment used to harvest or transport forest commodities may pose a risk for the movement of forest pests (see section 3.7 and section 3.13). Increasingly, NPPOs are establishing import

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Trucks loaded with logs and semi-processed wood are transported by ferry in Brazil requirements for the entry of such equipment (see section 4.14). Containers and other storage units could also be contaminated with pests, soil and forest-commodity waste (e.g. branches, leaves and other plant debris). Equipment and storage units should be cleaned after use and the contaminant materials disposed of in a manner that manages risks effectively, such as burning, deep burial, or reprocessing into other commodities. The IPPC's Sea Container Task Force provides guidance on means for reducing the spread of pests by sea containers (IPPC Secretariat, 2020a, 2020b). Note that, in some countries, local environmental or waste management regulations may influence decisions on how material can be treated or disposed of. The relevant authority should be consulted before proceeding.

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[8] See Annex 1 of IPPC Secretariat. 2016. *Categorization of commodities according to their pest risk.* International Standard for Phytosanitary Measures No. 32. Rome, FAO on behalf of the Secretariat of the International Plant Protection Convention.

3 Good practices for forest health protection

Diverse species of insects and microorganisms may be present on trees, exploiting their leaves, bark, wood and roots for shelter and food. Forest products, therefore, could contain such organisms. Many species considered pests in some importing countries may not be deemed pests in their native ranges. Thus, forest products from both healthy forests and forests experiencing disease or insect outbreaks may pose a pest risk and a threat to international trade.

Good forest health should be a minimum aim of sound commercial forest management. This chapter provides basic information on IPM practices for all phases of, and sites involved in, forest resource management, including:

- forest operations – planning, harvest and transportation;
- forest nurseries;
- planted forests;
- naturally regenerated forests;
- post-harvest treatments and sawmills; and
- product transportation, distribution and storage.

Many pest management practices, such as sanitation, surveillance, diagnostics and quick reporting to the NPPO, are applicable to all phases of forest management and can be selected and adapted to individual conditions. It should be noted that, in some countries and situations, it may not be possible to implement all potential best practices, particularly after disasters and other unexpected events that may create economic constraints and require immediate actions such as salvage.

3.1 INTEGRATED PEST MANAGEMENT IN FORESTRY

IPM is the most effective way to deal with forest pests. It can be defined as a combination of prevention, observation and suppression measures that are ecologically and economically efficient and socially acceptable in order to maintain pest populations at acceptable levels. Prevention may include the use of pest-resistant tree varieties, tree–site matching and selection, natural regeneration, and planting, pruning and thinning practices that reduce pest populations and favour sustainable control by their natural enemies. Careful monitoring of pest populations, for example through visual inspection and trapping systems, determines when control activities are needed. For suppression, mechanical control, biological control through the use of natural enemies and biopesticides, and other sustainable control methods are preferred over the use of synthetic pesticides. IPM relies on understanding the biology of host plants and pests as well as the biology of natural control agents that can help keep pests under control.

For IPM to be effective, therefore, field staff must be trained to recognize pests, monitor population levels and use biological control agents and other suitable control methods.

The often-shifting focus of forest management (e.g. from fibre extraction, to recreation, to wildlife conservation), along with the globalization of trade and travel and the accompanying problem of biological invasions, has increased the complexity of pest management. Innovations such as biotechnology tools (e.g. gene mapping and molecular pest detection through environmental DNA/RNA monitoring) and digital and smart technologies (e.g. remote sensing, smartphone apps, unmanned aerial vehicles and autonomous equipment and vehicles) have helped improve forest pest management. These new technologies work best when their deployment is coordinated and standardized.

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Release of Pauesia *parasitoids for biocontrol of the cypress aphid,* Cinara cupressi, *in western Kenya*

Biological control through the use of natural enemies is an essential component of IPM. Beneficial natural enemies may be encouraged through suitable silvicultural practices (biological control by conservation) and supplemental releases (biological control by augmentation), the latter including the use of biological pesticides based on microbial diseases of pests. A third approach commonly used in forestry, classical biological control, consists of controlling non-native pests, including weeds, by importing natural enemies (e.g. parasitoids, predators and pathogens for pests and arthropod herbivores and phytopathogens for weeds) from their country of origin. This approach has been carried out successfully for well over a century. Over time, however, practitioners have become aware that introduced biological control agents may have undesirable side-effects. Initially, this concern was limited to the possible impact of these introduced agents on economically important plants and insects (notably honeybees, silk moths and weed biological control agents). More recently, increased environmental awareness has drawn attention to the potential danger to native fauna and flora, particularly rare and endangered species. ISPM No. 3 (IPPC, 2017a) provides guidelines for the safe use of exotic natural enemies in biological control programmes. When considering biological control agents, it is essential to have information on the pest (its identification, importance and known natural enemies), the natural enemies (identification, biology, host specificity, hazards to non-target hosts, their own natural enemies and possible contaminants, and procedures for their elimination), and human and animal health and safety issues. The decision on whether to use a biological control agent may depend on economics and science-based estimates of the likely results versus the economic and environmental costs of other control options (such as pesticides) and the cost of doing nothing and accepting losses due to the pest.

Regulatory guidelines that normalize the use of natural enemies can influence the implementation of biological control measures. Legal frameworks for effective, efficient access and benefit-sharing regulations that facilitate biological control need to be established between involved parties.

3.2 FOREST OPERATIONS

Forest operations personnel can minimize pest movement through careful operational planning, harvesting, wood storage and transport (see also section 3.8). For example, personnel involved in pre-harvesting surveys, harvesting and other forest activities can be trained to recognize and report unusual pests and symptoms of diseased or infested trees and to carry out practices that reduce the risk of pest populations moving to other locations.

Minimizing pest populations during harvesting and processing will reduce the incidence of pests in the commodity before export and facilitate safe transport. This is particularly important if the harvested wood is to be moved internationally. The potential impacts of phytosanitary measures on trade can be reduced by identifying and reporting unusual pests to the NPPO, particularly if the pest is detected early (see section 4.6) and can be eradicated. In addition to pests directly

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Debarking infested logs at the harvesting site can help avoid the spread of pests. Here, workers in Honduras are using hand tools to remove bark from logs infested with the southern pine beetle, Dendroctonus frontalis

associated with wood, attention should be given to "contaminating pests" (also known as hitchhikers) that do not use wood as a host, and to soil adhesions in raw wood, which may contain soil-borne pests such as nematodes, fungi and fungus-like organisms. Box 4 provides guidance on operational practices in forests to reduce pest presence.

Phytosanitary considerations are particularly important when targeting international markets but need to be balanced against other important forest resource management objectives, such as those associated with biodiversity, recreation and fire management. Economics and local regulations are also important factors in forest operations decision-making.

BOX 4 Planning and operational practices that can minimize pest presence in forests

- Select tree genotypes that are appropriate for a given site. Trees will be more susceptible to attack by insects and pathogens if they are not well-suited to the soil or climate.
- Identify pest outbreaks during field planning and report these to pest professionals. If relevant, report them to the national plant protection organization (NPPO) or other relevant authority. Species not viewed as pests in one country may be considered so in another.
- Record all pest outbreaks and where they occur. This will assist in determining pest-free areas in the future.
- Conduct systematic surveys to detect and assess increases in forest insect populations and the prevalence of pathogens and the associated damage. Report unusual pest occurrences to forest managers, NPPOs, forest landowners and other stakeholders in a timely manner.
- Use knowledge of pest development biology and weather events to predict pest emergence and choose optimal times for applying control measures.
- Consider harvesting stands with a high incidence of dead or dying trees to prevent more losses of stock and to reduce the risk of pest spread. Extract and burn dead trees on-site or use the wood locally to avoid spreading pests to other areas.
- Depending on the pest risk of the organism(s) in question, chipping and leaving chips on site may be an effective alternative to burning and the local use of the wood.
- Consider the layout of harvest boundaries to reduce the risk that trees remaining after harvest might blow down and provide food for pest buildup.
- Prevent erosion and the subsequent weakening of trees, which can make them more susceptible to pests, using harvesting practices appropriate for the landscape.
- Avoid causing damage to standing trees during forest operations, which can affect vigour, enable infection by wood-degrading fungi, and increase susceptibility to other pests.
- Remove felled trees from the forest quickly to avoid the buildup and outbreak of pests.
- Avoid soil adhesion to wood.
- When felled trees must be stored in or near a forest, consider removing the bark. This will help avoid spreading pests such as certain wood borers and bark beetles.
- Consider keeping log piles moist with sprinklers or submerging logs in ponds or storing them under impermeable cover such as foil, plastic or tarps to increase carbon dioxide and deplete oxygen and thereby reduce bark-beetle attack and sapstain fungi/discolouration of the wood before processing.

- Transport logs during the dormancy period of known pests and apply appropriate control measures at the final destination before the pests emerge.
- When moving or storing wood originating from natural disturbances such as storms and fire, ensure that operations do not enable the spread of pests.
- Where appropriate, store wood under cover, under water-sprinkler systems or in ponds, and install pheromone or light traps in log depots to reduce the risk of pest infestations and outbreaks and their spread to surrounding areas.
- Properly dispose of, or otherwise manage, debris from harvesting, thinning and pruning to ensure that associated pests do not spread to other areas.*
- Sanitize machinery, other equipment and transport containers and remove soil to avoid pest transfer.
- Allow the harvesting of branches for commercial purposes (e.g. Christmas trees and tree parts) only in areas that are not infested with pests.
- Provide foresters, forest owners and other stakeholders with training in the recognition of key pest species and their damage and on the procedures for reporting pest occurrence.

* In some countries, local environmental or waste management regulations may influence decisions on how material may be treated or disposed. Check with the relevant authority before proceeding.

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Storing wood with bark in a water-sprinkler system (left) or under impermeable cover (right) will help minimize the risk of spreading pests such as certain wood borers and bark beetles. It will also help prevent the wood from becoming infested by storage-wood pests and protect the wood from discolouration due to sapstain fungi

3.3 FOREST NURSERIES

Because forest nurseries may supply plants for planting as a commodity to many geographic areas, keeping pests out of them is imperative. Buying healthy stock and carefully monitoring the condition of seedlings and cuttings are important practices. If possible, new plant materials should be kept separate from the main growing areas and observed for a certain period to ensure they are not pest carriers. Forest nurseries tend to use intensive management practices that, if improperly applied, can promote pest buildup. The artificial environments of nurseries (e.g. in terms of planting density, species and clone choices, and monocultures) can be favourable for pest development.

To minimize damage, it is essential to detect and treat pests before they spread. Operational procedures should require that workers who observe symptoms of pests that are unknown in the nursery report this immediately to their managers for further investigation. In nurseries involved in international trade, specialists in plant health and plant protection and with a working knowledge of pest identification and control should be available (see also ISPM No. 36 – IPPC Secretariat, 2019a). Nursery managers should notify the NPPO or other relevant authority if an unknown organism or an important or regulated pest is found. Box 5 provides further guidance on good nursery practices.

If forest nursery plants are intended for international trade, it is necessary to follow the importing country's phytosanitary requirements. A phytosanitary certificate may be required to certify to the NPPO of the importing country that the consignment has been inspected and found free of regulated pests and that it fulfils phytosanitary import requirements (see section 4.10).

BOX 5 Good nursery management practices that minimize pest presence

- Provide the best possible growth conditions (e.g. nutrients, water, light, appropriate spacing and weed control) to raise healthy, vigorous and resistant plants.
- Harvest seed from good-quality, genetically superior trees; use multiple sources of planting material to increase genetic diversity; use certified seeds if possible and store seeds in conditions that limit pest attack; test seeds before planting to ensure good germination and seed health; apply seed treatments, if needed; determine, if possible, the resistance of seeds to the main pests; and multiply and distribute resistant stock.
- Locate nurseries away from commercial stands to reduce the risk of contamination and the subsequent spread of pests. Keep new plant material isolated from the main growing areas and monitor for a specified period to ensure it is pest-free.
- Keep records that enable identification of the sources of production material and where it has been grown and planted out so that the source of any infestation or infection can be traced.
- Use soil or an inert growing medium that is free of insects, pathogens and weed seeds.
- If necessary, treat soils to kill pests before planting.
- Establish monitoring systems to enable the early detection of pests. Use adhesive traps to detect the presence of insect pests and spore traps to detect fungal spores.
- Take immediate action if pests are detected.
- Use appropriate preventative silvicultural, chemical or biological control methods.
- Ensure that irrigation water is free of pathogens and other contaminants such as pesticides, particularly if the water source is a pond where water accumulates from infected or treated fields or is suspected of being contaminated. Install filtration systems to sanitize infested water.
- Avoid leaving leaves wet, especially when watering at night, because this can facilitate infection by pathogens. Use trickle irrigation rather than sprinklers to help keep leaves dry.
- Install screens or nets in plant production facilities to prevent insect entry and spread.
- Inspect materials before transport to ensure that plants are free of pests.
- Assign a plant health and protection specialist.
- Cooperate with the national protection organization (NPPO) at an early stage of production if the intention is to export plants to third countries.
- Notify the NPPO or other relevant authority if an unknown, important or regulated pest is found.

- Rotate crops to avoid recurring pest problems; make sure the alternative crop is not susceptible.
- In infested areas, limit the entry of visitors to reduce the risk of pest spread via their clothing and footwear. Measures to limit the entry of animals and birds, which may spread pests, should also be considered.
- Clean (i.e. thoroughly remove all soil and plant materials from all surfaces and crevices) and, if necessary, disinfect all tools, footwear and equipment before entering and leaving the nursery, especially if a pathogen is present. Clean and disinfect tools used for different operations within the nursery before and after use.
- Dispose of infested soil or growing media carefully to avoid contaminating other plants and soil.
- Collect and remove dead plants and debris every week to decrease the probability of infestation. Destroy or sanitize infested plant waste by burning, composting or treating with heat to kill the pest. If composting, make sure that the temperature is sufficient to kill the pest.
- Use deep burial (to a depth of 2 m) to dispose of plant waste that cannot be destroyed or sanitized by other means.*

* In some countries, local environmental or waste management regulations may influence decisions on how material may be treated or disposed. Check with the relevant authority before proceeding.

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Forest nursery, Angola

3.4 PLANTED FORESTS

Planted forests face many health threats from pests at all stages of management, from planting or regeneration to harvesting. Many pathogens and pests can spread in seeds or on seedlings. Good nursery health, therefore, is essential for producing vigorous forest plants that are adapted to and free of pests. Other important practices include pest surveillance and monitoring and sufficient oversight to ensure compliance with phytosanitary requirements. The use of appropriate genetic material that meets provenance (geographic origin) and species requirements and the suitable size and type of seedlings or cuttings is also important for ensuring good forest health. Choosing the most appropriate species for a site's soil and climatic conditions reduces plant stress and thus susceptibility to infestation by pests. Understanding local pest status can help avoid establishing susceptible species in conditions that favour the pest.

Field surveys, including evaluations of forest health, can help in the early detection of pests and ensure prompt action. Weed control can promote tree growth and facilitate silvicultural activities, but the potential negative effects of weed control, such as soil erosion and biodiversity loss, should also be considered. Box 6 provides further guidance on planting practices.

Pests can be spread from one location to another during the movement of site-preparation equipment and in routine silvicultural activities such as pruning and thinning. Proper cleaning and sanitizing of equipment is therefore important. Equipment, tools, footwear and vehicle tyres should be cleaned of soil and organic matter before spraying with a disinfectant, such as industrial alcohol, when working in areas infected with pests of quarantine significance. Flame sterilization can be used for some kinds of tools. If none of these is available, vigorous washing with steam or soap, if available, will reduce risk.

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Planting a diversity of species (e.g. in blocks) can help reduce susceptibility to forest pests; trees planted in this forest in Viet Nam are a combination of pine and acacia

BOX 6 Good planting practices to minimize pest presence

- Be aware that monocultures and clonal plantations can be more vulnerable than mixed forests to pests.
- Avoid reliance on a single tree species or a single clone, especially over large areas.
- Consider that disturbances are more common in single-aged forests than in multi-aged forests.
- Choose provenances (geographic origin) and tree species well-suited to the site and climate to ensure strong, healthy plants.
- Select appropriate growing sites to ensure healthy plants and minimize future pest problems.
- When selecting a non-native tree species for planting, consider its potential to become a pest.
- Be cautious when moving plants with soil; if possible, use bare-root seedlings and clones for planting out.
- Move bare-root plants when they are dormant and thus less likely to spread forest pests (this also reduces plant stress and thus susceptibility to pests). The potential for termite attack should be taken into consideration when planting bare-root seedlings and clones.
- Provide healthy growing conditions for planted-out stock, ensuring sufficient water, sunlight and nutrients to avoid stress.
- Manage unwanted plants in planted forests to promote tree growth.
- Provide adequate spacing for field-planted seedlings and clones to reduce their susceptibility to pests.
- Consider appropriate site-preparation practices to ensure good drainage and root growth.
- Remove soil and organic matter from footwear and equipment (e.g. tools and vehicles) and disinfect these before entering and leaving a forest area, particularly if the site is infested, to reduce the spread of pathogens that cause diseases such as root rot. Clean tools after each use.
- Survey often to ensure the health of the plants.
- Where appropriate, use thinning (e.g. pre-salvage, salvage and sanitation) to maintain stand health and vigour, reduce pathogen inocula, and remove insect-pest brood trees.
- Where silvicultural waste from pruning and thinning might be a breeding substrate for pests, dispose of it properly by burning, deep burial, composting or heat treatment sufficient to kill the pests.*
- Notify the national plant protection organization or other relevant authority if an unknown organism or an important or regulated pest is found.

* In some countries, local environmental or waste management regulations may influence decisions on how material may be treated or disposed. Check with the relevant authority before proceeding.

Silvicultural activities such as spacing, pruning, thinning, weed management and fertilization may be practised as planted forests mature, depending on the management objectives and resources available. Forest managers must be vigilant to preserve and enhance forest health during these management activities.

Pest management can be complex for agroforestry systems, in which trees are integrated into farms and other agricultural landscapes. Pests may spread from agricultural crops to trees, and vice versa. Trees and crops may act as hosts or trap-crops for certain pests. Extra care must be taken when harvesting non-wood forest products, particularly fruit and nuts, to minimize damage to the plants that might provide entry points for pathogens and pests. Similarly, pest management can be multifaceted in urban forests,[9] which are often susceptible to pest outbreaks due to factors such as fragmented habitats, environmental stressors, altered ecosystems and increased human activity. Many urban centres feature diverse native and non-native tree species, which can act as hosts for invasive pests and facilitate pest spread.

3.5 NATURALLY REGENERATED FORESTS

Forests may regenerate naturally after harvesting through natural seeding or the sprouting of roots and stumps. In some forests, understorey plants present before harvesting may complement the natural seeding process, although this might require silvicultural treatments in the years before harvest to ensure that these existing plants, called “advance regeneration”, are present and vigorous. In addition, some forest practices may include leaving certain high-quality mature trees (seed trees) in the stand to encourage natural seeding.

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Natural Pinus sylvestris *forest with regeneration, Türkiye*

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[9] Urban forests are networks or systems comprising woodlands, groups of trees and individual trees in urban and peri-urban areas.

In some cases, natural regeneration will be more resilient to environmental stresses than planting stock brought onto a site because the species are adapted to the site and likely to grow more vigorously. Using natural regeneration also reduces the likelihood of introducing pests that might be present in plants for planting stock.

Regardless of the method, the reforestation of any site requires planning and follow-through. In some cases, the use of certain management and harvesting practices can promote natural regeneration and minimize ecological impacts, such as tilling the soil to obtain an optimal seedbed. Soil preparation might be especially important for tree species that mast (i.e. synchronously produce full seed crops) only irregularly (e.g. oaks, beeches and teak) if those seeds are to be used for forest regeneration.

Before tree harvesting, surveys should be conducted of the advance regeneration present at a site to enable steps to be taken to ensure that harvesting doesn't damage those plants and they are best able to compete with weeds and become part of the regenerating forest.

Whatever regeneration method is used, it is important that sufficient stocking of the desired tree species is achieved to meet management objectives. Monitoring and pest surveys can help determine whether the regeneration is sufficiently free of competition from weeds, understorey species and other plants. Preventative measures should be employed to ensure that silvicultural activities such as thinning, pruning and fertilization do not facilitate the movement of pests or intensify their impacts (Box 7).

3.6 SAWMILLS AND POST-HARVEST TREATMENTS

It is important to process and transport roundwood promptly and carefully after harvest to reduce existing pest populations and minimize opportunities for new pests to attack the wood. If sawmilling will not occur immediately, pest risk can be reduced by using various post-harvest treatments and storage methods. Treated commodities for export should be kept isolated to minimize the risk of post-treatment infestation.

All roundwood should be examined visually on arrival at the sawmill for signs of pests. Ideally, log suppliers should alert sawmill operators about any potential pest problems. Signs of unusual pests should be investigated and reported to the NPPO or other relevant authority. The proximity of the storage site to the forest is an important determinant of whether pests can spread from stored forest products to forests.

Even when it is planned to move harvested trees during a pest's dormancy period, seasonal weather patterns may change the timing of pest emergence. Actions may therefore be necessary in storage areas (either in the forest or at the sawmill), such as bark removal, the placement of pest traps, and the application of cover sprays. For example, the cut surfaces of oak logs intended for the production of valuable wood-based panels such as veneers are typically treated with wax to prevent oxidation and reduce humidity. Some sawmills sprinkle water on log

BOX 7 Good practices for naturally regenerated forests that minimize pest presence

- Choose the most appropriate regeneration process, or combination of processes, to ensure healthy, vigorous forests.
- Conduct regular surveys to determine the success of the regeneration process and to check for pests.
- Choose the most appropriate silvicultural, pest-protection and harvesting practices to promote regeneration and reduce pest populations in the regenerating forest.
- Ensure appropriate spacing between naturally regenerated plants to reduce susceptibility to pests of concern and promote tree growth.
- Manage non-target (unwanted) plants and trees to promote tree growth.
- In circumstances where it can be a breeding substrate for pests, properly dispose of biomass generated by pruning and thinning.*
- Perform activities such as pruning, thinning and the harvesting of non-wood forest products (e.g. nuts, bark and resin) during periods of low risk so that wounds do not allow the entry of pathogens and other pests.
- Clean and disinfect footwear and equipment (e.g. tools and vehicles) before leaving a site, particularly where the risk of spreading pathogens and other pests is high. Disinfect tools after use.
- Notify the national plant protection organization or other relevant authority if an unknown organism or an important or regulated pest is found.

* In some countries, local environmental or waste management regulations may influence decisions on how material may be treated or disposed. Check with the relevant authority before proceeding.

piles, submerge logs in ponds or snow, or store logs under impermeable cover (e.g. foil, plastic or tarpaulin) to reduce bark-beetle attack and sapstain fungal discolouration until the wood can be processed. Forecasts can also be developed to predict when pests are likely to emerge and spread. These may range from simple systems based on experience or more complex models based on host and pest development biology and climate data. An example of the former is the observation that bark-beetle survival is likely to be higher after a mild winter, which could lead to increased damage or faster spread. Local experts can advise sawmill operators on practical solutions for the pests likely to be present locally.

Ensuring that vehicles and other equipment used to transport wood from the forest to a sawmill are cleaned of bark, plant debris and soil immediately after unloading is good practice and will reduce the risk of accidental pest introduction and spread. For wood suspected of infestation, the use of coverings and enclosed trucks or containers may minimize the risk of pest escape during transportation.

Bark and other residual products should be gathered and stored securely for later use or safe disposal. It is common for pests to be present in residual or waste materials, which need to be properly managed to prevent pest infestations near the sawmill. The biology of the pests present in an area needs to be considered when deciding on storage for further use.

Processed wood and wood products should be monitored and graded to remove products showing signs of pest presence, such as decay, insect holes and frass (borer debris and excrement). This quality-grading step provides further assurance that the products being delivered or dispatched are less likely to cause pest outbreaks. Those products that are removed because of pest risk should be safeguarded and processed or disposed of safely. Treating pests with heat, irradiation or fumigation may be an option; the damage remaining after treatment, such as insect holes, sapstain and discoloration, may be acceptable, depending on the intended use and quality recommendations. Box 8 lists general good practices for sawmills.

3.7 PRODUCT TRANSPORTATION AND DISTRIBUTION CENTRES

The import and export of forest commodities, primarily wood products, may involve seaports, handling facilities, airports and train depots for the unloading and loading of containers and ships. Given the large number of forest commodities in movement and storage, appropriate pest management in these areas and facilities is crucial for preventing the spread of pests.

Storage areas for forest commodities in import/export facilities should be built on hard or permanent surfaces (e.g. paving, concrete or gravel) and be free

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Sorting wood in a sawmill in Canada

BOX 8 Good practices for sawmills and post-harvesting treatments to reduce pest spread

- Minimize log storage in forests – transport felled logs to sawmills as soon as possible.
- Where practical, consider on-site treatment of freshly felled logs.
- Examine harvested logs before entering the sawmill to determine whether pests are present and to enable preventative action.
- Set aside logs with advanced decay so that rotten sections can be removed and used or disposed of in ways that safeguard the remainder. This will also reduce the amount of visual examination required in the production process.
- Notify the national plant protection organization or other relevant authority when new, important or regulated pests are discovered or if there appears to be a potential pest outbreak in harvesting, manufacturing or storage areas.
- If feasible, debark or store log piles using water-sprinkler systems, in ponds or under impermeable cover to reduce existing or potential infestations. Place pheromone or light traps strategically to reduce insect infestations.
- Transport infested loads in covered, enclosed trucks.
- Clean vehicles that transport logs and remove bark and debris for safe disposal immediately after unloading.
- To prevent pest buildup and spread, continually gather up bark and debris in storage yards for further use or safe disposal.*
- Monitor all products during the manufacturing process for the presence of pest indicators. Separate infested products for safe use or disposal to prevent the movement and spread of pests.
- Store infested products awaiting disposal in a separate area to avoid the contamination of pest-free products.
- Post-harvest treatment with heat, irradiation or fumigation may reduce risk for certain pests. Contact your national plant protection organization for information on phytosanitary import requirements in target markets and on suitable treatments for your specific products and the pests associated with them.

* In some countries, local environmental or waste management regulations may influence decisions on how material may be treated or disposed. Check with the relevant authority before proceeding.

of vegetation, dead or dying trees, refuse and soil. It is important that the areas adjacent to wood stockpiles are also kept free of pests.

To avoid cross-contamination, imported wood and wood for export should be stored separately, with adequate buffer zones between them. Similarly, treated and untreated wood should be separated. If places are assigned for wood fumigation, insect-proof physical barriers should be constructed to avoid the recontamination of treated wood.

Potential pest infestation sources, such as rejected logs, dunnage, broken wood pieces and plant waste, should be removed promptly and disposed of safely to avoid pest buildup.

Forest commodities have the potential to become infested or contaminated with pests during storage, loading and transport. Containers should be inspected before loading to ensure that no pests are present and that remnant soil and debris do not pose a pest risk. Container-cleaning programmes using pressure washing or sanitation treatment may be necessary. Written procedures are needed to ensure worker safety and the achievement of phytosanitary goals.

Immediately before loading, it is advisable to inspect the products to ensure they have not been infested or contaminated while in storage. The record of this inspection can also serve as a monitoring record if pests are detected during inspection at the destination.

The proximity of transportation and distribution centres to forests greatly influences the probability that outgoing consignments can become infested with pests. Similarly, the proximity of forests to such centres influences the probability of successful pest establishment due to the availability of suitable habitat. Where product entry and exit facilities are near forests, it is useful to conduct surveys or other monitoring to detect any new forest pests (see section 4.6). In some cases, trees near product entry and exit facilities can serve as sentinel or indicator plants. Such trees or plants can also be planted at points of entry such as ports and container terminals. Alongside regular surveys, sentinel trees and other plants can help detect forest pests entering the country. Monitoring tools such as pheromone and light traps and regular survey sites are recommended to help detect certain insect pests, such as bark beetles, ambrosia beetles and some wood borers. Trap-logs can be effective for monitoring wood borers and some bark beetles.

Some insects, such as the spongy moth (also known as gypsy moth) (*Lymantria dispar dispar*, particularly the Asian subspecies (*L. d. asiatica*) and the burnt pine longhorn beetle (*Arhopalus ferus*), are attracted to light. To manage risk for such species, it can be helpful to minimize the intensive lighting at ports and on vessels during periods of high risk and to conduct loading operations and arrange departure times at periods of low insect activity. Predeparture inspections or treatments of consignments and conveyance may also be necessary.

Practical working solutions for improving pest management in import/export facilities and thus protecting forest health can be developed by working with local scientists and NPPOs (Box 9).

BOX 9 Good practices for product transportation and distribution centres to reduce pest spread

- Build forest product storage areas on hard surfaces (e.g. paving, concrete or gravel), which should be maintained free of potential pest infestation and contamination from sources such as soil and debris.
- Dispose of potential pest infestation or contamination sources such as waste from conveyances and broken products.*
- Implement standards and procedures for cleaning containers to ensure pests are not moved during the transportation process.
- Inspect products and remove infested materials and contaminating pests before loading.
- Prevent cross-contamination between imported and exported products and between treated and non-treated products.
- Keep treated wood packaging material (see ISPM No. 15; IPPC Secretariat, 2019b) separate from untreated wood packaging. Do not load treated wood onto untreated wood packaging.
- Recycle or reuse off-loaded dunnage and wood packaging material, in consultation with the national plant protection organization (NPPO).
- Implement monitoring programmes, including trapping, in those areas where entry and exit facilities are adjacent to forested areas, in collaboration with the NPPO.
- Promote awareness of pest infestations near seaports and develop systems to ensure that conveyances and consignments are clean of contaminating (hitchhiking) pests, including egg masses.
- Work with the NPPO to develop practical solutions for managing the risk of pest movement at facilities where forest product imports and exports are concentrated.

* In some countries, local environmental or waste management regulations may influence decisions on how material may be treated or disposed. Check with the relevant authority before proceeding.

3.8 USING A SYSTEMS APPROACH TO MANAGE PEST RISKS IN FORESTS

Plant health regulators are increasingly recommending systems approaches as an alternative to single treatments to reduce the risk of pests and meet import requirements. A systems approach is a pest risk management option that integrates different measures, at least two of which act independently, with cumulative effect (ISPM No. 5). Foresters often apply best practices to reduce pest problems throughout the entire production process, from planting and managing forests to harvesting operations and the production of wood products. Combining these practices or measures as the basis of a systems approach is similar to the process for developing an IPM system (see section 3.1 and section 4.5). Box 10 gives examples of pest management measures that foresters can use to reduce pest populations before and after products are sold and dispatched.

BOX 10 Examples of forest pest risk management measures that may be included in a systems approach

Before trees are planted

- Register seed and plant producers and provide training in proper handling methods.
- Select appropriate genetic material.
- Select healthy planting material.
- Select pest-resistant or less-susceptible species and varieties.
- Identify pest-free areas for the location of (for example) nurseries, plantations and processing sites.
- Consider ecological characteristics, such as soils, vegetation, biodiversity and other resource values, in planning and site selection and preparation.

In the growing phase

- Perform inspections to detect pest presence.
- Test for pathogens such as root-rot fungi (e.g. *Phytophthora* spp.).
- Deploy practices such as the disruption of pest breeding, preharvest treatments, biological control and pheromone trapping to reduce pest populations and sanitation to remove potential pest-breeding substrates.
- Reduce pest populations using appropriate silvicultural practices, such as sanitation to remove potential breeding substrates, and avoid damaging crops during operations such as weed control, thinning, pruning, the harvesting of non-wood forest products and tree salvage.
- Conduct sufficient surveys to certify low pest prevalence.

At harvest

- Harvest trees at a specific stage of development or time of year to prevent increases in pest populations.
- Inspect and remove infested trees and logs.
- Use sanitation practices, such as removing waste that could be potential breeding substrates for pests.
- Use harvesting and handling techniques that minimize damage to trees and soils.
- Remove felled wood quickly to avoid pest buildup, especially during periods of insect pest flight.
- Debark trees as soon as possible after felling.
- Where necessary, remove stumps or treat surfaces to reduce root rot and other pest problems.
- Clean equipment before moving between sites.

Post-harvest treatment and handling

- Treat logs and other wood products to kill, sterilize or remove pests using measures such as heat, fumigation, irradiation, chemical treatment, washing, brushing and debarking.
- Store logs and other wood products in ways that reduce pest buildup, such as under water or tarpaulins.
- Inspect and grade logs and other wood products.
- Use sanitation measures such as the removal of infested parts of host plants.
- Sample and test forest products for pests.
- Install insect screening or insect traps in storage areas.

In association with exports and imports

- Treat or process forest commodities to manage pests.
- Apply phytosanitary restrictions at end use, distribution and points of entry.
- Impose restrictions on import timing where this can help avoid pest introduction.
- Select appropriate methods of wood product packing, such as closed or covered containers, to prevent pest infestation and accidental escape during transport.
- Require that plants imported to an area undergo a quarantine period to enable the detection of latent infestations (post-entry quarantine).
- Inspect and test products to verify pest status.
- Use good sanitation practices for conveyances such as ships, containers and trucks.

3.9 PREVENTING PEST SPREAD VIA WOODFUEL

Woodfuel is a broad category that includes roundwood, wood residues, wood chips, wood pellets, fuelwood, charcoal and black liquor. The international woodfuel market continues to grow as countries seek sources of renewable energy to replace fossil fuels (Box 11). The trade in wood pellets has surged in recent years, particularly in Europe and North America (FAO, 2019), increasing the associated pest risk. The risk is lower for processed products: pellets and charcoal, for example, may not need regulation aimed at reducing pest risk.

BOX 11 Volume of woodfuel traded internationally, by type (average 2015–2019)

- Charcoal – 2 564 400 tonnes
- Wood chips and particles – 68 493 000 m^3
- Fuelwood – 8 569 600 m^3
- Wood residues (wood waste) – 6 999 800 m^3
- Wood pellets and other agglomerates – 22 809 200 tonnes

Source: FAO (2021).

Trees damaged by pests are frequently cut for woodfuel. Many of the pests that cause trees to decline or die can survive in wood for several years, with the potential to be transported to new areas. Woodboring beetles (e.g. emerald ash borer – *Agrilus planipennis* – and Asian longhorned beetle – *Anoplophora glabripennis*) are serious pests that frequently spread through this pathway. European woodwasp (*Sirex noctilio*), termites and pathogens can also be transported on or in logs and branches used for woodfuel.

It is increasingly evident that even the domestic movement of woodfuel products can exacerbate pest spread. National regulations may be needed to prohibit their movement from infested to pest-free areas – such as those adopted by some countries to minimize the domestic spread of the Asian longhorned beetle.

Some countries have import regulations requiring that fuelwood is subject to heat treatment or fumigation to reduce pest risk. These are easier to monitor and enforce for large commercial operations, and smaller operations may lack the capacity to meet the requirements. Enforcement of regulations on individuals moving fuelwood is almost impossible. Public education may be the best approach for reducing the spread of pests via fuelwood.

For international transportation, regulations for roundwood often apply to fuelwood. Treatments such as debarking and chipping can greatly reduce the survival of bark beetles, but heat treatment and fumigation have greater capacity to reduce the risk of fuelwood pests, including fungal pathogens, that live deeper in the wood. Treated fuelwood should be protected to avoid post-treatment infestation, such by storage in appropriate areas or with covers.

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Even the domestic movement of fuelwood can spread pests

3.10 PREVENTING PEST SPREAD VIA PLANTS FOR PLANTING

Many forest pests are believed to be introduced to new locations and hosts via plants for planting. This commodity may include roots, stems, branches and leaves, and sometimes even fruit. With so many plant parts, the material has the potential to carry diverse pests, although plants in growing media (unsterile soil) are generally considered higher-risk. Pathogens are particularly hard to detect in plants for planting. Examples of pathogens believed to be spread by plants for planting include horse chestnut bleeding canker (*Pseudomonas syringae* pv. *aesculi*); ash dieback (*Hymenoscyphus fraxineus*); pitch canker (*Fusarium circinatum*); and several *Phytophthora* species, including *P. alni*, *P. cinnamomi*, *P. kernoviae*, *P. lateralis*, *P. pinifolia* and *P. ramorum*.

There is little scientific literature on the pests associated with ornamental plants. Moreover, scientists estimate that as little as 7 percent of the world's fungi is known to science. Some pathogens hybridize in nursery environments to create new organisms better-adapted to new conditions and hosts. Special culturing methods and molecular tools, such as DNA sequencing (e.g. polymerase chain reaction) and immunological detection (e.g. enzyme-linked immunosorbent assay kits), may be needed to confirm the presence of pathogens. These tools, and the time needed to use them, are rarely available to inspectors assigned to monitor imported plant materials. Undetected pathogens may spread via plants for planting and establish in natural ecosystems, causing damage to native species, ecosystems and commercial operations.

Pest risk has increased significantly since the rise in volume of the ornamental plant trade as a result of shifts in global plant production. Often, given the huge volume of trade and the way in which consignments are typically sent (packed

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A forest nursery, Egypt

tightly in containers), only small samples of the plant material are inspected (usually visual inspection only). Current regulatory systems screen for regulated pests, but some pests are difficult to detect and some are not yet known. Some plants may look healthy while containing latent or dormant pathogens. It is a huge pest management challenge to support the plant trade while also minimizing pest spread and preventing devastating impacts on natural ecosystems. A possible solution may involve developing systems that reduce pest incidence throughout the production process. The European Union, which comprises a single market of 27 countries with few border controls between them, uses a "plant passport" system, whereby authorities inspect producers of high-risk nursery stock to confirm that nurseries are pest-free before authorizing the producers to issue plant passports, which accompany the plants to the final end user. This system enables regulatory personnel to track down the sources of infested plants quickly and thereby reduce pest spread within the European Union.

Also needed are ongoing updates of scientific databases, data sharing, and improved inspection and (especially molecular-based) diagnostic methods. In general, efficient growing techniques to produce the healthiest plants are recommended. Other measures may include the efficient tracking of plant origin and voluntary or regulated exclusion of some types of commodities at highest risk, such as large plants for planting with soil used to create "instant" tree landscapes. Education to raise awareness of the potential danger and global scale of the problem is also important.

In response to this high-risk pathway, the IPPC adopted ISPM No. 36, *Integrated measures for plants for planting*, in 2012 (IPPC Secretariat, 2019a).

3.11 PREVENTING INTENTIONALLY INTRODUCED TREE SPECIES FROM BECOMING PESTS

Many non-native plant and animal species that have been introduced deliberately into ecosystems outside their native ranges for their economic, social or environmental benefits have subsequently become serious pests. This is of considerable concern in the forest sector: for example, non-native tree species are often used in agroforestry and commercial forestry and to combat desertification, and many such species are valued for their adaptability to diverse sites, their rapid growth and the multiple uses of their products. In some cases, however, such species have become serious ecological threats (Box 12). It is vital to ensure that introduced species serve the purposes for which they are introduced and do not become pests.

Careful pest risk assessment is recommended before introducing new plant species. For example, the weed risk assessment described by Pheloung, Williams and Halloy (1999) has proven reasonably accurate over a broad range of ecological conditions (Gordon *et al*., 2008).

BOX 12 Examples of intentionally introduced tree species becoming pests

The following are examples of non-native tree species used in the forest sector that have caused serious environmental problems in their introduced environments.

- *Leucaena leucocephala* is used widely as a source of wood, woodfuel, fodder and shade and to restore degraded lands, improve soils and stabilize sands. It is a fast-growing, nitrogen-fixing tree that is tolerant of arid conditions and saline soils, and many people in arid regions of Africa and Asia hold it in high regard. The species tends to form dense thickets, however, and readily invades forest margins, roadsides, wastelands, riparian areas and agricultural lands and suppresses the growth of other woody and herbaceous species (Sharma *et al.*, 2022). It is now considered one of the 100 worst invaders in the world (GISD, 2024) and is an environmental weed and invasive plant in many regions in Africa, Asia, Europe, Oceania, North America and South America (Sharma *et al.*, 2022).
- *Prosopis juliflora* is used to help control soil erosion, reduce the aridity of an area, provide a source of woodfuel, and produce fodder and shelter for wild and domesticated animals. It has been introduced into many countries in Africa and Asia, with significant socio economic and environmental impacts. The species displaces native flora, thereby reducing biodiversity and the diversity of products available to rural communities (Nascimento *et al.*, 2014; Tadros *et al.*, 2020).
- Commercial tree species such as pine (*Pinus* spp.), eucalypt (*Eucalyptus* spp.) and rubber (*Hevea brasiliensis*) are important sources of wood, fibre and latex and thus have been planted in many areas where they are not native. Several of these species have spread outside the areas in which they were planted, sometimes with devastating impacts on ecosystems, such as reduced landscape values, increased fire risk, disruption of existing vegetation dynamics, and depletion of soil nutrients and water reserves (Kourantidou, Haubrock and Cuthbert, 2022).
- Many *Acacia* species have been introduced worldwide for timber, woodfuel and tannins for reforestation purposes and dune stabilization and as ornamental plants. These species have resulted in a range of negative impacts in regions where they are invasive. Invasive acacias have facilitated declines in native plant species diversity, decreased the abundance and richness of native invertebrates, altered chemical properties of the surrounding soils, reduced water resources, and negatively affected native plant germination and growth (Del Vecchio, Acosta and Stanisci, 2013; Jansen and Kumschick, 2022; Pauchard *et al.*, 2023). Socio economic impacts include declines in grazing land for livestock, increased labour costs to prepare crop fields, and interference in cultural and spiritual practices (Jansen and Kumschick, 2022; Pauchard *et al.*, 2023).

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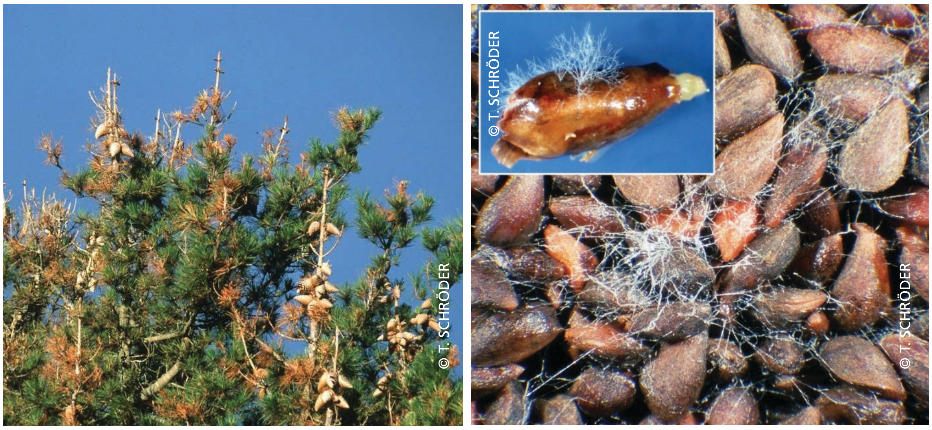
Many forest tree species, such as this young Acacia albida *in the Niger, are planted for the positive benefits and products they provide but have the potential to become invasive*

3.12 PREVENTING PEST SPREAD VIA SEED MOVEMENT

Forest tree seeds may harbour seed-borne or seed-transmissible harmful organisms; these are mostly fungi, although insects that develop in seeds may also be present. Harmful bacteria, viruses, viroids, phytoplasmas and nematodes may also be present on tree seeds, although these are generally of secondary importance. The impacts of seed-borne and seed-transmissible pests include reduction in seed germination, direct damage to plants (at the seedling stage or later), and introduction and spread to new areas where other host plants are infested.

International trade in forest-tree seeds may contribute to the spread of seed-



Dieback caused by Fusarium circinatum *on* Pinus *(left) and seed damage caused by* Caloscypha fulgens *in Monterey, United States* borne and seed-transmissible pests. Depending on whether seeds are orthodox or recalcitrant, seeds may be dried or frozen, which will affect the survivability of potential pests. Conifer seeds, for example, are usually dried and can also be stored at sub-zero temperatures. Fungi can survive such storage to some extent, but it will kill most insect stages. Seeds used to establish forest stands are often subject to more stringent quality requirements than tree seeds of the same species intended for non-forest purposes.

Examples of seed-borne, tree-damaging fungi on hardwood seeds are *Cryphonectria parasitica* on *Castanea sativa* and *Quercus* spp.; *Ophiognomonia clavigignenti-juglandacearum* on *Juglans* spp.; and *Ceratocystis fagacearum* on *Quercus* spp. Examples on softwood seeds include *Sirococcus conigenus* on *Picea* spp. and *Sphaeropsis sapinea* and *Fusarium circinatum* on *Pinus* spp. In addition, seed-borne fungi, such as *Caloscypha fulgens,* can reduce seed germination. Seed-transmissible insects include *Megastigmus* spp. for *Abies* spp.; *Curculio* spp. for *Quercus* spp.; and *Bruchus* spp. for *Acacia* spp.

Another important source of harmful organisms in seedlots is plant debris as contaminants (e.g. *Pinus* needles infested with *Dothistroma septosporum*) and other seed species that can act as invasive species when introduced to new areas. From production, harvesting, treatment and storage to the traded seedlot, there are various ways to minimize or eliminate pest infestation in seeds (Box 13).

BOX 13 Good practices for minimizing or eliminating pests in the production and movement of seeds

Pre-planting

- Use healthy seeds and resistant provenances for the establishment of seed-production stands.
- Select good locations for seed-production stands and manage these well to ensure production of high-quality seeds.

At harvest

- Depending on the harvesting method, clean and disinfect equipment and conveyances before use.
- To ensure high-quality seeds, harvest in years of high seed production (i.e. full mast).
- If seeds, cones and fruit cannot be harvested directly from a tree, use nets or impermeable materials on or above the forest floor to avoid contamination and infestation with fungi that sporulate on plant material on the ground (e.g. *Ciboria batschiana* on *Quercus* acorns and *Caloscypha fulgens* on *Picea* and *Abies* cones).

Continues ..

Post-harvest treatment and handling

- If intermediate storage is necessary, prevent overheating, especially of recalcitrant seeds.
- When processing seeds (e.g. extracting from fruit, collecting on the forest floor, or heating cones to release the seeds), use methods that do not damage the seed.
- Use techniques such as wind sifting and wash-off to remove insect-infested seeds and plant debris.
- Store only vigorous seeds.
- Aspects that influence the quality of the final seed product are seed storage and seed testing, and certification can provide a guarantee of quality. The phytosanitary import regulations of third countries may require specific testing regimes (ISPM No. 31; IPPC Secretariat, 2011) or evidence that the seeds originated in pest-free areas (see section 4.8). It is often difficult to determine whether a batch of seeds is free of infestation because the presence of fungi, bacteria, viruses and nematodes is usually not visually detectable. Laboratory examination may be necessary, requiring a certain quantity of seeds for examination.

3.13 PREVENTING PEST SPREAD VIA THE MOVEMENT OF USED VEHICLES, MACHINERY AND EQUIPMENT

Large equipment is used in many parts of the world in forest operations such as wood harvesting (e.g. harvesters, forwarders, skidders and cable cranes), road construction (e.g. earthmoving equipment such as trucks, bulldozers and graders) and firefighting. Other types of equipment commonly employed in forest operations include chainsaws, turning hooks, axes, shovels, planting hoes and that used for cone harvesting (e.g. pole pruners).

Such vehicles, machinery and equipment (VME) may carry remnant soil and plant parts, including seeds, and contain pests ranging from fungi to nematodes, bacteria, viruses and insects. Seeds may serve as a pathway for harmful organisms, or the plant

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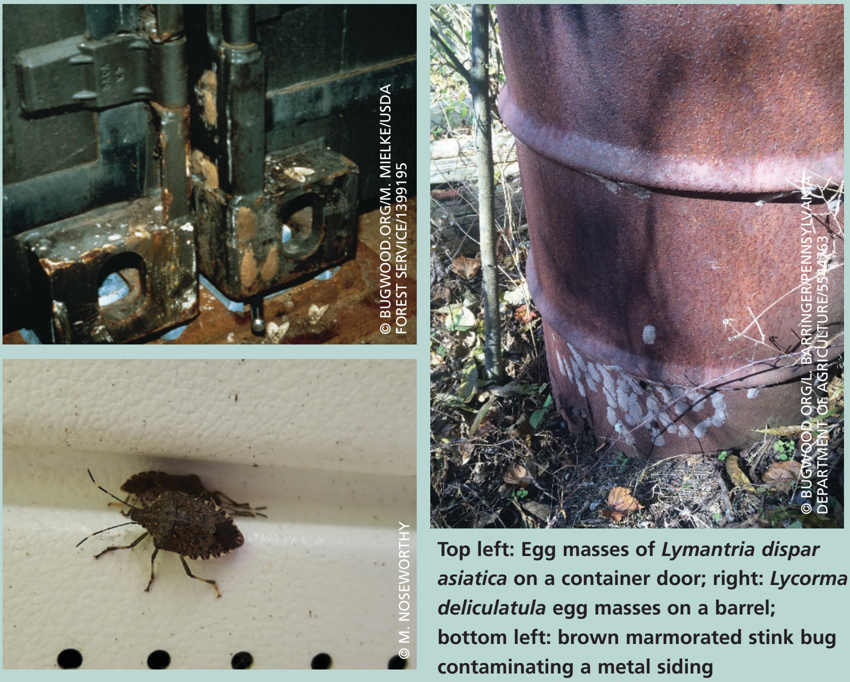
Equipment used in forestry operations, such as this tractor and excavator (left) and chipper (right), can spread unwanted pests grown from the seed itself may be a pest. Contamination by insects laying egg masses (hitchhikers) on VME is also possible (Box 14). In the absence of adequate sanitation practices, therefore, using the same equipment at different locations, including in countries that import used VME, poses a pest risk.

BOX 14 Contaminating or hitchhiking pests

A contaminating pest is a pest that is carried by a commodity, packaging, conveyance or container or is present in a storage place and which, in the case of plants and plant products, does not infest them (ISPM No. 5; IPPC Secretariat, 2023a). These pests, also referred to as hitchhiking pests, are unintentionally introduced via products or conveyances they are not infesting.

Contaminating pests can be found in any substrate. The attraction of pests to substrates other than their hosts may be explained by the pest's biology and conditions of the substrate. For example, insects in Lepidoptera are attracted to light; those in Hemiptera are attracted to cracks and crevices; Coleoptera insects are attracted to host volatiles; and Gastropoda are attracted to moist environments. Contaminating organisms may be attracted to specific conditions and may choose a wood substrate to increase their chances of survival by avoiding predators or seeking shelter from weather events, and to nest; they may also arrive passively.

Contaminating organisms may be more difficult to predict and guard against than infesting pests.



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Top left: Egg masses of *Lymantria dispar asiatica* on a container door; right: *Lycorma deliculatula* egg masses on a barrel; bottom left: brown marmorated stink bug contaminating a metal siding

The pest risk associated with used VME depends on several aspects. Larger, more complex machinery may have more hard-to-reach areas and thus be harder to sanitize. VME used in forest operations is likely to be contaminated with organic material, soil and forest pests. VME stored outside and close to vegetation or under artificial lighting may be at risk of contamination with hitchhiker pests such as *Lymantria dispar*, *Lycorma delicatula*, *Halyomorpha halys* and *Trogoderma granarium*, even after sanitation. The intended use of VME in the destination country is another important factor determining whether importation of the VME poses a significant pest risk.

Harmful organisms and seeds can be moved around and between forests via the movement of VME. The pest risk may be low for VME moved to closely related sites or forest types because of the pre-existence of similar pest species at the new site, but it may be unacceptably high for VME moved to forests where the pests are not already present. In areas where pest eradication measures have been implemented, the entry of used VME may compromise those efforts. Phytosanitary measures to reduce pest risk for the movement of used VME to new sites (including internationally) include inspection, cleaning, the treatment of any existing contamination, and the prevention of new contamination after the sanitation process (Box 15).

BOX 15 Good practices for minimizing the spread of pests on used vehicles, machinery and equipment

- Remove all contaminants (e.g. soil and plant debris) and contaminating organisms from all vehicles, machinery and equipment (VME) before moving to a new site.
- Clean used VME by removing stagnant water and contaminants such as soil and plant debris. Suitable cleaning methods may include compressed air, pressure washing, hot-water or steam cleaning, abrasive blasting, sweeping, and vacuuming. Such methods may be combined with chemical or thermal treatment (hot or cold).
- It may be necessary to (partially) dismantle VME to clean hard-to-reach areas (e.g. by removing gearbox protection, underride protection and chainsaw housings).
- Clean internal spaces, such as operators’ cabs.
- After cleaning and before shipping used VME to other countries, undertake applicable phytosanitary measures, if any, to prevent new contamination during storage and transport.
- Consider and protect against seasonal pest emergence, as well as pest attraction to light, at storage and loading areas.
- Carry out inspections during cleaning and shipping to ensure that the phytosanitary requirements of importing countries are met. The national plant protection organization of the importing country may require documentation, such as phytosanitary certificates.

Source: FAO (2021).

4 Phytosanitary concepts simplified

In this chapter, section 4.1 describes the IPPC and how ISPMs[10] are developed and adopted and sections 4.2–4.16 outline the guidance contained in the ISPMs most relevant to forestry (listed and referenced at the beginning of each section).[11] ISPMs support good forest practices as well as pest-free trade in forest commodities and in other commodities traded using WPM. The descriptions in each section assume ideal implementation of the standards and follow IPPC definitions. Some IPPC contracting parties may implement ISPMs differently (e.g. because of limited resources). Countries may prescribe stricter phytosanitary import requirements than those established in ISPMs but must provide a technical justification for doing so. Contracting parties may file claims of unjustified trade restrictions, and the IPPC provides a dispute-resolution process for dealing with such claims.

4.1 INTERNATIONAL STANDARDS FOR PHYTOSANITARY MEASURES

The process of developing new or revised ISPMs is managed by the IPPC's Standards Committee. ISPMs are developed and approved through a transparent and inclusive international consultative process. They are recognized under the WTO's Agreement on the Application of Sanitary and Phytosanitary Measures (also called the SPS Agreement) as the only international standards for phytosanitary measures.

ISPMs are based on scientific principles, existing trade policies and technical information. Drafts are developed initially by phytosanitary experts who are members of IPPC technical panels or working groups. The Standards Committee reviews these draft standards and prepares them for country consultation, which provides IPPC contracting parties with the opportunity to comment on and suggest revisions to the draft standard, often after national-level consultations with affected industries, government departments and other stakeholders. The Standards Committee revises the draft based on the inputs received from contracting parties and may recommend it for adoption by the CPM. The process to develop a new ISPM can take several years.

The Technical Panel on Forest Quarantine, which operated between 2005 and 2021, addressed forest-related quarantine issues, working closely with the

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[10] Annex 3 contains the titles and summaries of all ISPMs. Note that the year in which the ISPM was originally created is given alongside its number (e.g. ISPM No. 2, 2007). In this document, the latest version of the ISPM is cited by its publication year (e.g. IPPC Secretariat, 2016a).

[11] The IPPC publishes guides and training materials to help NPPOs build capacity and implement ISPMs effectively. These are available via the IPPC website, at https://ippc.int.

Technical Panel on Phytosanitary Treatments and the International Forestry Quarantine Research Group (an independent body of research scientists and representatives of national regulatory agencies and the forest sector). IPPC expert groups now carry out the functions of the Technical Panel on Forest Quarantine, as needed.

Contracting parties to the IPPC are required to:

- set up an NPPO;[12]
- designate official IPPC contact points;
- certify exports;
- cooperate internationally;
- share information on pests and regulations; and
- cooperate on the development of ISPMs.

Contracting parties may also prescribe and adopt phytosanitary measures and regulate imports.

NPPOs are the government agencies in IPPC member countries that implement phytosanitary standards by developing and enforcing national regulations. They undertake PRAs for the establishment of phytosanitary measures; manage pest surveillance; report to other countries on pest status; coordinate the control of pests; and establish and monitor pest-free areas. When required, they issue phytosanitary certificates confirming that consignments have met an importing country's requirements. They also take responsibility for ensuring phytosanitary security of consignments after certification and before export; conduct verification inspections; and, as necessary, require the treatment or destruction of consignments, or refuse entry to them.

Because pests do not recognize international borders, NPPOs work frequently with neighbouring countries to prevent pest entry, establishment and spread between countries. Such collaboration may be through RPPOs. These assist in coordinating regulations to deal with regional phytosanitary issues raised by NPPOs – they gather and disseminate information and may identify priorities for regional standards (which may, in turn, become the basis of new ISPMs). Usually, NPPOs (but sometimes RPPOs) request the IPPC to develop a new ISPM or revise an existing one to deal with a particular phytosanitary issue.

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[12] The full list of NPPOs and RPPOs and their contact persons can be found at www.ippc.int.

4.2 PEST RISK ANALYSIS

Framework for pest risk analysis (ISPM No. 2, 2007) (IPPC Secretariat, 2016a)
Guidelines for the export, shipment, import and release of biological control agents and other beneficial organisms (ISPM No. 3, 2005) (IPPC Secretariat, 2017a)
Pest risk analysis for quarantine pests (ISPM No. 11, 2013) (IPPC Secretariat, 2017b)
Pest risk analysis for regulated non-quarantine pests (ISPM No. 21, 2004) (IPPC Secretariat, 2021a)

Pest risk involves a wide range of organisms that can potentially be associated with forest commodities, including bacteria, fungi, insects, mites, molluscs, nematodes, viruses and parasitic plants. Each country evaluates the pest risk associated with the trade of a given forest commodity. They must ensure that their phytosanitary import requirements draw on science-based risk analysis, are proportional to the pest risk, and have minimal impacts on trade.

PRAs can be carried out for particular pests, commodities (and the pests they might carry) from a particular country or region of origin, and pathways. PRAs for proposed import commodities have several steps. First, a clear description is needed of the commodity and the processes that have been applied to it. A draft list of pests potentially associated with the commodity is then prepared from the scientific literature and from historical records of pests that have been detected in association with the commodity in other countries.

Next, each potential pest is assessed on:

- whether it is present in the exporting and importing countries;
- whether it is associated with the commodity or other pathway;
- whether it can enter the importing country, find suitable habitats there, and establish and spread;
- whether, and to what extent, it will cause economic and environmental damage in the importing country if it becomes established; and
- the management options available to reduce pest risk.

PRAs require an understanding of the ecology and behaviour of each potential pest, including its range of suitable hosts, life stages, method and rate of reproduction, life-cycle length, and climatic requirements. The potential impacts of the pest on industries, the environment and international trade are also evaluated. The result of this process is an assessment of the pest risk for each organism. The consideration of the risk of pests associated with a particular commodity, group of commodities or conveyance is referred to as a pathway risk analysis.

The assessment of pest risk is one of the inputs to a PRA and will determine the need for phytosanitary measures; PRAs also includes consideration of various phytosanitary measures to manage pest risk. A lack of information is often a major constraint in assessing pest risk for forest commodities. For example, there may be insufficient information about the organisms associated with a commodity, including their entry, establishment and spread and on effective treatments or measures to reduce risk. Potential obstacles for obtaining suitable information for PRAs include the language of source publications; limited or no access to databases; and an inability to predict the economic or environmental impacts. Insufficient or inadequate information will increase the uncertainties associated with a pest risk assessment and could lead to more restrictive import requirements than necessary to minimize risk.

4.3 REGULATION OF WOOD PACKAGING MATERIAL

***Regulation of wood packaging material in international trade* (ISPM No. 15, 2009) (IPPC Secretariat, 2019b)**

WPM is often used to support, protect or carry goods during transport. WPM includes pallets and pallet collars, skids, boxes, crates, packaging blocks and cases, cable drums, spools and reels, dunnage, and other wooden units used in containers and the holds of aircrafts and ships to secure trade goods. WPM is sometimes made with low-quality raw wood and, untreated, it can provide a pathway for significant forest pests, such as the Asian longhorned beetle (*Anoplophora glabripennis*) and pinewood nematode (*Bursaphelenchus xylophilus*). The pests may occur at the surface of the wood (e.g. bark beetles, if bark is present; moths and other insects; and fungi) or within the wood (e.g. woodboring beetles, nematodes and fungi).

ISPM No. 15 was developed in recognition of this high-risk pathway. Adopted in 2002 and revised in 2009, ISPM No. 15 requires that WPM is treated for pests

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Examples of wood packaging subject to ISPM No. 15: pallets, Hungary (top left); cable drums, France (top right); pallet collars, Germany (bottom left); crates with stone slabs (centre left); and dunnage between concrete forms before its use in international trade and recognizes two treatments: heat, and fumigation. Heat treatment may involve the use of various energy sources and processes, such as conventional heat treatment (steam, and kiln-drying); heat-enabled chemical pressure impregnation; and dielectric heating (microwave and radio frequency). Conventional heat treatment ensures a temperature of at least 56 °C for 30 minutes throughout the entire profile of the wood (including the core). In practice, this is often done by developing verified heat treatment schedules for different types of wood and initial moisture and different types of kilns to achieve target heat exposure. Dielectric heating requires wood to be heated to a minimum temperature of 60 °C for one continuous minute throughout the entire profile of the wood (including the surface). Fumigation may be carried out using methyl bromide or sulfuryl fluoride at specific concentrations and timings using specified procedures. See ISPM No. 15 and related documents published by the IPPC for more details on the practical application of heat and fumigation treatments.

ISPM No. 42 contains requirements for the use of temperature as a phytosanitary treatment, and ISPM No. 43 provides technical guidance on fumigation as a phytosanitary treatment.

ISPM No. 15 requires that WPM is made of debarked wood, irrespective of the type of treatment applied. For methyl bromide and sulphuryl fluoride treatments, the debarking process must occur before treatment because the presence of bark may affect the efficacy of the fumigation. For heat treatment, bark removal may be carried out before or after treatment.

Debarking is a process in which most of the bark is removed from a harvested tree. It does not necessarily result in wood that is completely free of bark (i.e. bark-free wood);[13] ISPM No. 15 includes a tolerance for small pieces of bark, if the pieces are separate and distinct. Long thin pieces of bark are allowed to remain after the debarking process, but these must be no wider than 3 cm, regardless of length. If the pieces are wider than 3 cm, they must be short; no single piece of bark can have a surface area greater than 50 cm^2.

Fumigant gases such as methyl bromide and sulphuryl fluoride can have negative impacts on the environment. For example, methyl bromide emissions are known to deplete the ozone layer, and sulphuryl fluoride is a recognized greenhouse gas. The use of other approved treatments is recommended, therefore, to avoid negative environmental impacts associated with fumigant-gas treatments. Many countries have already banned the use of methyl bromide under the Montreal Protocol,[14] and others have announced their intention to do so. New technologies, such as recapture and chemical breakdown, are being developed to help reduce the environmental impacts of fumigants.

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[13] Bark-free wood is wood from which all bark, except ingrown bark around knots and bark pockets between rings of annual growth, has been removed. Debarked wood is wood that has been subjected to any process that results in the removal of bark but is not necessarily bark-free wood (ISPM No. 5) (IPPC Secretariat, 2023a).

[14] The Montreal Protocol on Substances that Deplete the Ozone Layer, with the following amendments: London 1990, Copenhagen 1992, Vienna 1995, Montreal 1997, Beijing 1999, Kigali 2016.

ISPM No. 15 states that treated wood must be marked with a box containing:

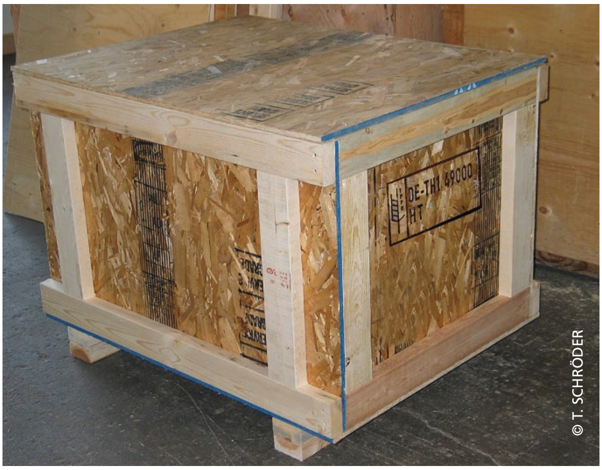
- the ISPM No. 15 symbol;
- a country code;
- a producer/treatment provider code; and
- a treatment code (e.g. HT = conventional heat treatment; DH = dielectric heating; MB = methyl bromide; and SF = sulfuryl fluoride).

The mark must appear on two opposite sides of the wood packaging unit. WPM that meets all these requirements is said to be compliant (see ISPM No. 15 for more information on the mark).

Treatments and the specific identification mark must be applied under the authority of the NPPO in the country of manufacture to ensure that the treatment providers are treating the wood to the ISPM No. 15 standard. The presence of an ISPM No. 15 mark provides an adequate basis for entry into countries; a phytosanitary certificate or other evidence of treatment is not necessary.

Any unit of wood packaging only needs to be treated once, as long as it remains intact and does not need to be repaired or remanufactured. However, when a unit of wood packaging is repaired (defined as the replacement of less than one-third of the wood in the unit), the repaired portion of the unit should be made with treated wood and each new component must be marked individually in accordance with ISPM No. 15. Alternatively, the entire unit can be re-treated and re-marked. When a unit is remanufactured (defined as the replacement of more than one-third of the unit), the entire unit must be re-treated, the old marks must be completely removed or destroyed, and a new mark must be applied.

Note that not all wooden articles that carry trade goods in international trade need regulation and treatment. Wood packaging made exclusively from manufactured wood such as plywood, fibreboard and oriented strandboard are unregulated because the processes used in their manufacture (involving heat, pressure and glue) ensure they will be pest-free. Barrels (e.g. whisky barrels) are not considered to pose a pest risk and are exempt from ISPM No. 15 if sufficient



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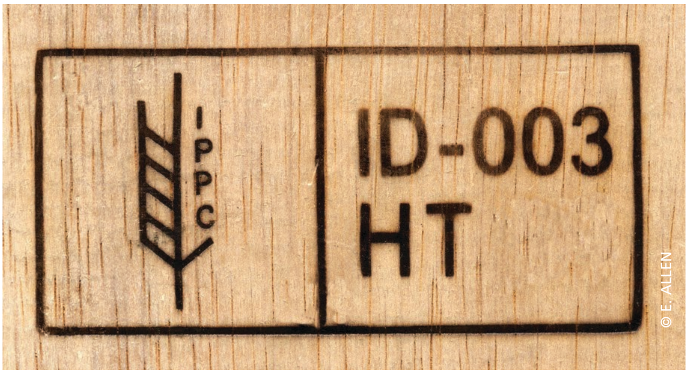
An example of wood packaging material in the United Kingdom that is subject to ISPM No. 15: it is composed of both raw wood (falling under ISPM No. 15) and processed wood (not falling under ISPM No. 15). For easy reading, the mark may be displayed on the processed wood



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An example of the IPPC mark on wood packaging material. It features the ISPM No. 15 symbol (in the left-hand box), an ISO two-letter country code (i.e. ID for Indonesia), a unique number (i.e. 003) assigned to the producer by the NPPO, and the ISPM No. 15 treatment code (i.e. HT for heat treatment)

heat is used in processing the staves and the wood packaging is made entirely of components less than 6 mm thick.

More information on implementing ISPM No. 15 is available in the IPPC guide to support implementation of ISPM No. 15 (IPPC Secretariat, 2023b). ISPM No. 15 is a good example of how forest industries and NPPOs have worked together to develop and implement phytosanitary measures.

4.4 PEST RESPONSE

Guidelines for pest eradication programmes (ISPM No. 9, 1998) (IPPC Secretariat, 2017c)

The NPPO or other appropriate body should be informed when a new pest has been introduced to an area. The NPPO may arrange for official diagnostic confirmation in order to decide on the most appropriate response, such as a PRA, official control, or an eradication programme. Where local diagnostic expertise is limited, the NPPO may contact another NPPO to which specimens can be sent for official identification (such collaboration can also save time). NPPOs are obliged to report the introduction of new pests to the IPPC (see section 4.7).

Once the establishment of a new pest has been confirmed, the possibility of eradication or containment should be evaluated. If the pest is considered to pose a serious risk, the response must be immediate if eradication is to be successful. The NPPO may wish to regulate the pest and initiate an official control programme to prevent further introductions. Even if the pest is too widespread to be eradicated, preventing further introductions will help keep the genetic diversity of the pest low and prevent more-virulent strains from entering the country.

Having a contingency plan (already approved by all stakeholders) in advance of finding a pest will save time in the planning stages of a response. Such plans should address what needs to be done, how it will be done, who will be responsible and who will pay. In many cases, implementation will require coordination between the NPPO, other government departments, local government authorities, industry sectors and commercial bodies. The knowledge and expertise of forestry experts is essential for the successful application of appropriate management measures. Contingency plans should be reviewed frequently to reflect new data and experiences in dealing with a given pest or those with similar characteristics, both locally and in other countries.

If no pest-specific plan is available, generic plans might still be useful. Although such plans will lack certain elements of pest-specific plans, they can provide a framework to enable the rapid development of effective action plans when new or unforeseen pests are detected.

The essential elements of a contingency plan are:

- understanding the biology and possible impacts of a pest;
- defining the objectives of the plan;
- establishing the response actions to be implemented (e.g. surveillance, sampling, pesticide registration, safeguarding potentially infested sites, regulatory actions and destruction of infested items);
- identifying who is responsible;
- testing the plan through simulation exercises;
- identifying the resource limitations of involved agencies;
- developing a communication plan (for stakeholders, partners, other NPPOs, the public and media); and
- determining if and when to initiate and conclude an eradication, official control or slow-the-spread programme.

To maximize the possibility of successful eradication, four important questions must be answered:

1. What is the current and potential pest distribution?
2. What are the pathways for entry into the area?
3. How does the pest spread?
4. How can the pest be controlled?

To determine the distribution of a pest and thus the area within which containment and eradication measures need to be taken, delimiting surveys (that is, surveys to determine the extent of spread of an introduction) must be conducted (see section 4.6). Depending on the pest's biology, the survey might need to be timed for when the signs or symptoms of its presence are most likely to be evident.

Good recordkeeping of the actions taken in an eradication effort will help in determining which measures worked best (and why), which measures were less effective (and why), and what might be done differently should an incursion of the pest occur in the future.

A way of determining the success of eradication needs to be developed on a case-by-case basis. For example, eradication might be declared a success if surveys fail to detect signs of the pest at any stage of its existence over a specified period – which should be at least twice as long as the life cycle of the pest.

The efficacy of the measures will need to be monitored and stakeholders will need to be kept informed, especially if changes in approach are under consideration. It is also important to share best control practices and related information at the global level to assist other NPPOs in dealing with similar pests and situations. The criteria for determining whether changes in pest-control approach are appropriate should be agreed on and communicated in advance to stakeholders, trading partners and neighbouring NPPOs. Ideally, stakeholders should be part of the review process: they are likely to have a better understanding of the potential impacts of proposed changes on their operations and may be able to suggest alternative approaches.

Sometimes it might not be possible to eradicate a pest. A procedure should be developed to help decide whether to initiate an eradication programme and (if so) when to stop it if it is proving ineffective. It may be necessary to change the strategy to a policy of containment and risk management. Box 16 presents an example of the evolution of a response strategy.

The appearance of a new pest, and the measures taken to control it, will inevitably have an impact on a wide range of stakeholders. It is important to ensure that stakeholders understand the potential impacts the pest might have, both in general and (where applicable) on their businesses. It is therefore recommended that stakeholders are identified and given the opportunity to comment on pest management options.

It is also important for stakeholders and others to understand the economic and other impacts of eradication measures, including the costs and benefits of potential actions. Such impacts might include the destruction of plants, the loss of biodiversity, revenues and export markets, and the cost of applying pre-export treatments to regulated commodities. An economic impact assessment can help determine when the cost of an action becomes more expensive than the losses incurred. Stakeholder support for measures is more likely when the risk posed by the pest and the pest eradication programme are fully understood.

BOX 16 Emergency response and exit strategy for the introduction of *Dendroctonus micans* to the United Kingdom

The great spruce bark beetle (*Dendroctonus micans*) is regarded as a major pest of spruce (*Picea* spp.), ranging from eastern Siberia to western Europe. It lives and breeds under bark, destroying the cambium and weakening – and, in extreme cases, killing – the tree. The beetle was first detected in the United Kingdom in 1982. Following confirmation, an outbreak management team was established consisting of personnel from the national plant protection organization and industry to develop a strategy for pest eradication. This strategy focused initially on surveillance, the control of wood movement, and the felling of potentially infested trees.

Surveillance showed that only parts of the country were infested. Those areas were brought under regulation so that the movement of wood outside infested areas was only permitted if the wood was bark-free or originated from identified pest-free areas. All trees found to be infested were felled and peeled of bark to remove obvious infestation, and the wood was taken to an approved sawmill for processing. For all logs with bark, movement was permitted only within regulated areas to an approved sawmill. To be approved, a sawmill had to install effective debarking equipment and have facilities available for managing bark debris.

Communication tools such as publicity leaflets and vehicle windshield stickers were developed on the pest risk and the phytosanitary measures established to manage this. An inspector was designated to provide advice and guidance to the industry, oversee surveillance, and monitor compliance at sawmills and other places. Penalties were imposed for offenders.

In the late 1980s, a fourth element was added to the management strategy when a biological control agent, the predatory beetle *Rhizophagus grandis*, was introduced and released. The containment programme was maintained to slow the spread of the great spruce bark beetle until populations of the predator became widely established.

Eradication efforts were abandoned in 2005 because the great spruce bark beetle had become so widespread that it no longer qualified as a quarantine pest. Outbreaks elsewhere in the country are now treated routinely by the release of

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The great spruce bark beetle (*Dendroctonus micans*) (left) and the predator *Rhizophagus grandis*

Rhizophagus grandis, and nature is allowed to take its course. The emergency response slowed the spread of the pest while scientists developed this long-term solution. Today, tree mortality has been reduced to less than 1 percent of infested trees, compared with 10 percent or more before introduction of the biological control agent.

4.5 SYSTEMS APPROACHES

The use of integrated measures in a systems approach for pest risk management (ISPM No. 14, 2002) (IPPC Secretariat, 2019c)

Use of systems approaches to manage pest risks associated with the movement of forest products (Regional Standards for Phytosanitary Measures No. 41, 2018) (North American Plant Protection Organization Secretariat, 2018)

A systems approach integrates different risk management measures, at least two of which act independently and cumulatively to reduce pest risk to a level at which the commodity can meet the phytosanitary requirements of the importing country.

Systems approaches enable the implementation of multiple risk-reduction measures that cumulatively reduce pest risk, from pre-planting through to final use. They can provide equivalent alternatives to single more-expensive and more-limiting measures such as pesticide treatment or prohibition of movement. For example, removing all bark from roundwood by squaring logs, combined with sawing the wood to specific dimensions and visual inspection of the wood during processing, may provide the same level of phytosanitary protection as fumigation. ISPM No. 24 provides more information on the equivalency of phytosanitary measures. A systems approach should be technically justified.[15] Box 17 provides an example of a systems approach to pest management in a wood product.

A systems approach in forestry manages the risk of pests in wood and wood products by using a combination of independent measures, from the selection of genetic material, to site preparation activities, to post-harvest treatment, to handling, to transportation and distribution (Figure 3). Many of the practices described in Chapter 3 can be used as part of a systems approach (see Box 10). A systems approach might integrate silvicultural practices such as pruning, thinning and tree salvage, as well as field treatment, post-harvest disinfestation, inspection and culling. It might also include risk management measures designed to prevent contamination or re-infestation, such as maintaining the integrity of lots, requiring pest-proof packaging, and screening areas where the commodity is assembled or stored. Procedures such as pest surveillance, trapping and sampling can also be incorporated as components of a systems approach. A systems approach might include measures that do not kill pests or reduce their presence but diminish the potential for pest entry or establishment. Such measures might include designated harvesting or shipping periods, certain conditions for the commodity (such as requiring that logs are debarked or fumigated, or both), the use of resistant hosts, and limiting distribution or restricting use at the destination.

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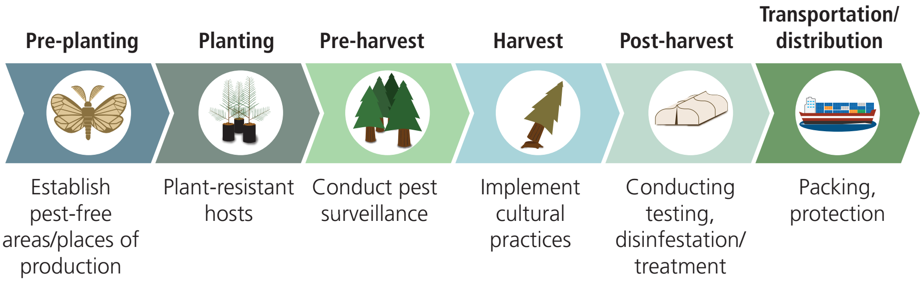
[15] "Technically justified" is defined in ISPM No. 5 as "justified on the basis of conclusions reached by using an appropriate pest risk analysis or, where applicable, another comparable examination and evaluation of available scientific information" (IPPC Secretariat, 2023a).

Systems approaches are generally complex, involving multiple measures that must be monitored, certified and verified to ensure that pest population sizes remain within acceptable limits. They can, however, enable flexibility in using

FIGURE 3

Examples of measures implemented along a forest product supply chain that could be incorporated into a forest product systems approach to pest risk management


Pre-planting
Planting
Pre-harvest
Harvest
Post-harvest
Transportation/ distribution
Establish pest-free areas/places of production
Plant-resistant hosts
Conduct pest surveillance
Implement cultural practices
Conducting testing, disinfestation/ treatment
Packing, protection

Source: M. Noseworthy.

BOX 17 Application of a systems approach for the export of ash sawnwood

Following the detection and widespread establishment of the emerald ash borer (*Agrilus planipennis*) in North America in the early 2000s, many countries* importing ash sawnwood from Canada and the United States implemented import regulations that challenged the North American industry. By studying the biology of the beetle and understanding where in the tree the insect life stages occur, a systems approach was developed that makes use of existing production practices to reduce pest risk to an acceptable level. These include:

- **Debarking** – all bark is removed, with the exception of small pieces smaller than 3 cm in width or with a surface area less than 50 cm^2.
- **Sawing** – boards are sawn from debarked roundwood, removing most of the outer rounded surface where emerald ash borer life stages are usually found.
- **Heat treatment** – sawnwood is heated in a kiln to achieve moisture reduction. This drying process is carried out for 1 200 minutes at 71 °C, exceeding heat treatment requirements for the emerald ash borer.
- **Drying** – sawnwood is dried following industrial schedules for at least two weeks, to a moisture content of less than 10 percent.

These processing practices can serve as independent phytosanitary measures. None provides sufficient protection on its own; when they are applied together as part of

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Processing ash logs at a sawmill in Ontario, Canada, in preparation for export. Top left: ash logs are debarked; top right: ash logs are sawn into boards; and boards are treated with heat in a kiln

a systems approach, however, the risk of emerald ash borer survival is extremely low. No reports of emerald ash borer have been made for sawnwood exported from North America under this systems approach since 2016, when it was introduced.

* See, for example, Commission Implementing Decision (EU) 2016/412 of the European Union (European Union, undated).

best practices to address pest risk when a single measure is not economically or biologically feasible, environmentally sound, or technically available.

4.6 SURVEILLANCE

Guidelines for surveillance (ISPM No. 6, 2018) (IPPC Secretariat, 2018)

The terms "surveillance" and "survey" are often confused – survey is a component of surveillance. According to ISPM No. 6, surveillance is an official process that collects and records data on pest occurrence or absence by survey, monitoring or other procedures, such as literature reviews.

A country may engage in pest surveillance to:

- detect new pests for rapid eradication or containment;
- facilitate trade by providing information about pests and their distribution within a country; or
- justify the use of regulations to prevent the entry of a pest that does not occur in the importing country.

Surveillance activities may be required in various locations, especially storage sites where commodities are assembled for export; points of entry and nearby forested areas; and facilities that receive large quantities of imported goods. There are two main types of surveillance: general and specific. General surveillance, which is relatively passive, involves gathering information on the distribution of pests of concern. Specific surveillance is more active, involving surveys to obtain information on pests at specific sites (e.g. in harvesting areas and near sawmills, ports and airports) over defined periods. Certain plants and plant products (such as furniture) may be included in such surveys.

NPPOs are responsible for gathering and maintaining information for general surveillance. Various sources may be used, such as FAO, forest agencies, research institutions, universities, scientific societies (including amateur specialists), land managers, consultants, museums, the public, scientific and trade journals, pest databases and unpublished material.

The community can help by monitoring pests and reporting to the NPPO or other relevant bodies when new pests or changes in pest distribution are detected. Botanic gardens, arboreta and other locations that routinely plant exotic materials should also monitor for new pests. A well-organized diagnostic and reporting system would support such efforts.

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*A forester conducts a survey for red band needle blight (*Dothistroma septosporum*) in a forest in the United Kingdom (left) and records the data*

Specific surveys can be carried out to detect a particular pest, identify the extent of a pest's distribution, monitor the presence of a pest in an area or site, and document the absence of specific pests to support the designation of pest-free areas (see section 4.8). These are official surveys that follow a plan that is approved by the NPPO.

Methods for monitoring introduced pests will vary according to the species being monitored and the existing conditions. Surveillance activities for introduced pests should emphasize early detection – that is, before major damage occurs and before the pest species has spread over a large area. Potential monitoring tools include inspections of commodities and packing materials at points of entry, pheromone traps, visual surveys, aerial surveys, planting and monitoring of sentinel or indicator species, and monitoring of artificially stressed trees.

Locations receiving large quantities of imported goods are often the centre of infestations. Therefore, a survey for a pest that is only likely to be present as a result of a recent introduction might focus on possible entry points and pathways of spread (e.g. a specific type of imported nursery plant, a type of sawnwood, or a handicraft such as a wooden birdhouse or carving) and sites where imported commodities are stored, marketed or used as planting material. The survey methodology must be science-based. The survey procedures may be determined by the type of sign or symptom by which the pest can be recognized. Surveys are designed to maximize the probability of finding pests.

Personnel involved in surveillance activities should receive periodic training with updates in the identification of pests of concern, especially after agreements have been made with new trading partners or for new forest commodities. These responsible persons should be well-equipped and trained in sampling methods, the preservation and transportation of samples for identification, and recordkeeping. Diagnostic expertise is necessary for verifying the identity of pests, and international experts are often available to assist with diagnosis. Samples of identified pest specimens must be stored safely. These are called "voucher specimens" or "voucher cultures" and are useful for resolving disputes and confirming the identification of other specimens and should be kept in "reference collections". Maintaining a specimen is also necessary because taxonomic revision can lead to changes in a species' definition (e.g. when a single species is recognized to comprise a complex of species). When this happens, reference specimens should be re-evaluated to keep records up to date.

Data quality is important in both general surveillance and specific surveys. Records should be appropriate for the intended purpose – for example, to support specific PRAs, the establishment of pest-free areas, or the preparation of pest lists.

Reporting new pests should be encouraged through public education and awareness programmes. Public availability of information on the distribution, biology and description of pests will facilitate the reporting of new pest finds. Such information should be shared as early as possible – even for pests that have not arrived in a country but which have the potential to enter and establish. A clear structure for reporting new pests should be established.

4.7 PEST REPORTING

Pest reporting (ISPM No. 17, 2002) (IPPC Secretariat, 2017d)

Determination of pest status in an area (ISPM No. 8 [2021], 1998) (IPPC Secretariat, 2021b)

Signatories to the IPPC have an obligation to report pests when they are identified as potential threats to trading partners or neighbouring countries, such as new occurrences or changes in pest status. Official pest reports need to be made by the IPPC contact point (usually the NPPO).

Pest reports are necessary:

- when a new pest is found or there is a sudden increase or decrease in an established or new pest population;
- when the success or failure of pest eradication is verified; or
- in any unexpected situation associated with an established pest or change in geographical distribution (e.g. a rapid increase in pest populations, a change in host range, or the development of a new, more vigorous strain or biotype) that increases the pest risk to the reporting country, neighbouring countries or trading partners.

The detection of new pathways or the absence of pests discovered as a result of specific surveys should also be reported.

The rapid expansion of global trade and the small number of taxonomic experts make it difficult to maintain accurate pest lists for all forest commodities. Better international collaboration is needed to overcome this obstacle. The IPPC website (FAO, undated[a]) provides all official pest reports from member countries. The RPPOs of North America and Europe maintain web-based reporting systems for regional updates; these RPPO reports are not considered official IPPC pest reports, however, unless the country has requested the IPPC Secretariat to accept them as such and they are posted on the IPPC website (see FAO, undated[a]).

Pest reporting enables countries to adjust their phytosanitary requirements, based on PRAs, and to take measures as necessary to respond to changes in risk. It provides useful current and historical information for the operation of phytosanitary systems. Accurate information on pest status is essential; it provides the technical justification for phytosanitary measures and helps minimize unjustified interference with trade. Pest information that might affect planting and marketing choices can also benefit foresters and assist them in working with NPPOs in planning management measures.

4.8 ESTABLISHMENT AND RECOGNITION OF PEST-FREE AREAS AND AREAS OF LOW PEST PREVALENCE

Requirements for the establishment of pest free areas (ISPM No. 4, 1995) (IPPC, 2017e)

Requirements for the establishment of pest free places of production and pest free production sites (ISPM No. 10, 1999) (IPPC Secretariat, 2016b)

Recognition of pest free areas and areas of low pest prevalence (ISPM No. 29, 2007) (IPPC Secretariat, 2017f)

Exporting countries may establish official pest-free areas or areas of low pest prevalence and then negotiate agreements with importing countries to allow exports of regulated commodities from those areas, which may help them gain, maintain or improve market access.

A pest-free area (PFA) is defined as an area in which a specific pest does not occur. PFAs allow the export of plants, plant products and other regulated articles without the need for other phytosanitary measures. The official establishment of a PFA must be based on specific survey data, and PFA status must be reviewed periodically through intensive surveys or inspections during pest growing seasons. Documentation should be made available to other regulatory authorities on request. The IPPC website provides a platform for communication among NPPOs on PFAs (FAO undated[b]). Box 18 provides an example of the use of PFAs.

A pest-free place of production (PFPP) is a place of production where a specific pest does not occur, as determined by an NPPO, even though the pest may be present in the area. The absence of the pest must be demonstrated by scientific evidence, such as that provided by periodic surveys. Trading partners will expect, at a minimum, to see documentation supporting the PFPP declaration.

BOX 18 ***Lymantria*: an example of the use of surveys to identify pest-free areas to facilitate the movement of regulated articles**

Lymantria dispar dispar and especially an Asian subspecies, *L. d. asiatica*, is a serious pest of deciduous trees in eastern North America and lays eggs on many commodities and in conveyances. It is not present in western North America or Mexico, and nor does it occur in portions of eastern Canada and eastern United States. National plant protection organizations in North America conduct annual specific surveys to determine the distribution of the pest, using pheromone insect traps. The resultant pest information is used to define pest-free areas in eastern North America that permit exporters to move regulated articles from those areas to other non-infested areas.

PFAs and PFPPs are easier to establish in planted forests than in naturally regenerated forests, which generally have a wider distribution and larger variety of plants and potential pests. Therefore, identifying a specific PFA in a naturally regenerated forest would involve surveillance activities that are often too expensive to be practical. In planted forests, the challenge of undertaking surveillance is much more manageable where the hosts are planted in blocks contained within a non-host environment.

4.9 INSPECTION

Guidelines for inspection (ISPM No. 23, 2005) (IPPC Secretariat, 2019d)

Methodologies for sampling of consignments (ISPM No. 31, 2008) (IPPC Secretariat, 2016c)

NPPOs (or personnel authorized by those NPPOs) inspect consignments before export and at the point of import.

The exporting country performs inspections to ensure that consignments meet the phytosanitary requirements of the importing country at the time of inspection. If requirements are met, an inspection may result in the issuance by the exporting country's NPPO of a phytosanitary certificate for the consignment in question.

Import inspections, usually based on visual examination, are used to determine whether to accept, detain or reject an imported commodity. Inspectors verify the identity and integrity of the commodity and the effectiveness of the applied phytosanitary measure (such as treatments or systems approaches). But visual inspection of wood may be insufficient because many pests (e.g. nematodes) are

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Inspecting imported wood in Australia

impossible to see with the naked eye and bundles of wood are difficult to examine thoroughly. The collection of samples and laboratory analysis can help detect pests. It is useful to keep good records of pest interceptions on imports; these can help countries determine which commodities need more careful inspection in the future and which are at lower risk. Good records can also show which countries of origin repeatedly send commodities containing pests, and they can also be used to underpin negotiations between countries to make trade safer. The volume of commodities inspected should also be recorded so that changes in the infestation rate over time can be determined.

Where exporters repeatedly fail to comply with the phytosanitary regulations of importing countries (see section 4.11), it may be necessary to increase the intensity and frequency of import inspections or to suspend imports. The NPPO of the importing country should also contact the NPPO of the exporting country to identify the source of problems and suggest improvements.

4.10 PHYTOSANITARY CERTIFICATION

Phytosanitary certification system (ISPM No. 7, 2011) (IPPC Secretariat, 2016d)

Consignments in transit (ISPM No. 25, 2006) (IPPC Secretariat, 2016e)

Categorization of commodities according to their pest risk (ISPM No. 32, 2009) (IPPC Secretariat, 2016f)

NPPOs of exporting countries issue phytosanitary certificates to certify that consignments of plants, plant products and other regulated articles meet the phytosanitary import requirements of trading partners, such as demonstrating that treatments have been performed. The IPPC prescribes a model for such certificates in ISPM No. 12. Phytosanitary certificates should not be required by importing countries for wood products that have been processed and thus have no potential to introduce regulated pests. ISPM No. 32 provides guidance on which commodities need and don't need phytosanitary certification (see section 2.2 and section 2.3).

The basic elements of the phytosanitary certification process are:

- determining the relevant phytosanitary import requirements of the importing country;
- verifying that the consignment conforms with those requirements at the time of certification; and
- issuing a phytosanitary certificate that accurately describes the consignment by species and quantity.

The importing country's NPPO should make available official and current information concerning its requirements. The requirements for the country of destination may also be obtained by the exporter and supplied to the exporting country's NPPO. Individuals or organizations authorized by the NPPO may perform certain functions, such as commodity inspections and verification of treatment, before the NPPO issues a phytosanitary certificate.

Importing countries frequently specify requirements for phytosanitary certificates, such as the use of a specific language; completion in legible capital letters; and the use of specific units. Electronic phytosanitary certificates (ePhytos)[16] are increasingly common. The inspection or treatment before dispatch of a consignment may have a limited period of validity. A phytosanitary certificate may be rejected or additional information may be requested by the importing country if the certificate:

- is illegible, incomplete or a non-certified copy;
- includes unauthorized alterations or erasures, conflicting or inconsistent information, or wording that is inconsistent with the instructions or model certificates;
- fails to comply with the specified period of validity;
- certifies prohibited products; or
- describes the consignment in a way that does not correspond with the material imported.

Perpetrators of fraudulent certificates should be subject to legal action.

In some cases, international trade may involve the movement of consignments of regulated articles through countries without being formally imported. This kind of consignment is said to be “in transit”. Such movements may present a pest risk to the country of transit, especially if consignments are carried in open containers. Countries may apply technically justified phytosanitary measures to consignments in transit through their territories.

4.11 NON-COMPLIANCE NOTIFICATION

Guidelines for the notification of non-compliance and emergency action (ISPM No. 13, 2001) (IPPC Secretariat, 2021c)

When consignments do not meet phytosanitary import requirements, they are considered to be non-compliant, and the NPPO of the importing country will notify the NPPO of the exporting country. The exporting country’s NPPO needs to investigate the cause of the non-compliance and apply appropriate corrective actions to ensure that consignments are not rejected in the future.

Non-compliance notifications are provided when there is:

- a failure to comply with phytosanitary import requirements;
- detection of regulated pests;
- a failure to comply with documentary requirements (e.g. phytosanitary certificates);
- prohibited consignments or prohibited articles (such as soil) in consignments;
- evidence of failure of specified treatments; or
- repeated instances of prohibited articles in small, non-commercial quantities carried by passengers or sent by mail.

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[16] See the IPPC’s ePhyto Solutions website at www.ephytoexchange.org.

4.12 PHYTOSANITARY IMPORT REGULATORY SYSTEMS

Guidelines for a phytosanitary import regulatory system (ISPM No. 20, 2017) (IPPC Secretariat, 2019e)

An import regulatory system should consist of two components:

1. a framework of phytosanitary legislation, regulations and procedures; and
2. an official service (the NPPO) responsible for the operation or oversight of the system.

NPPOs have the sovereign right to regulate imports to achieve acceptable levels of protection, taking into account their international obligations, particularly those specified in the ISPMs and the WTO Agreement on the Application of Sanitary and Phytosanitary Measures. When a contracting party implements phytosanitary procedures and regulations, it should try to use measures that reduce pest risk to an acceptable level and have the least-negative impacts on trade. Forest plants (including seeds), wood, WPM (including dunnage), and used VME are examples of forestry articles that are regulated in many countries.

4.13 INTERNATIONAL MOVEMENT OF SEEDS

International movement of seeds (ISPM No. 38, 2017) (IPPC Secretariat, 2017g)

Seeds may present a pest risk when introduced to an environment in which pests associated with them have a high probability of establishing and spreading. ISPM No. 38 provides guidance on identifying, assessing and managing the risk of spreading pests through the international movement of seeds, including general tree seeds and forest tree seeds. It also provides guidance on procedures to establish phytosanitary import requirements to facilitate the international movement of seeds; the inspection, sampling and testing of seeds; and the phytosanitary certification of seeds for export and re-export.

A PRA should determine whether seeds subject to international movement are a pathway for the entry, establishment and spread of quarantine pests and the potential economic consequences of those pests in the PRA area, or whether the seeds are a pest themselves or a pathway and the main source of infestation of regulated non-quarantine pests. The PRA should consider the purpose for which the seeds are imported (e.g. field planting, research or testing) and the potential for quarantine pests to be introduced and spread and for regulated non-quarantine pests to cause economically unacceptable impacts when present with a population density above a specified threshold.

Specific phytosanitary measures may be used to reduce the pest risk associated with the international movement of seeds, including phytosanitary measures that might be applied before planting, during growth, at seed harvest, after harvest, during seed processing, storage and transportation, and on arrival in the importing country (see section 3.12). Phytosanitary measures can be used either alone or in combination to manage the pest risk. Subject to agreement by the importing country, an exporting country may meet the phytosanitary requirements of the importing NPPO by applying equivalent phytosanitary measures.

4.14 INTERNATIONAL MOVEMENT OF USED VEHICLES, MACHINERY AND EQUIPMENT

International movement of used vehicles, machinery and equipment (ISPM No. 41, 2017) (IPPC Secretariat, 2017h)

Diverse VME are used in forest-related activities such as road construction, silviculture, the harvesting of wood and non-wood products, and combating forest fires. Used VME may become contaminated with quarantine pests or regulated articles depending on their use, storage and transportation before export. When moved internationally as either a traded commodity or for an operational relocation (e.g. in the case of harvesters), used VME can carry soils, pests, plant debris and seeds and may therefore present a pest risk in the destination country. Depending on their use at the destination, VME could introduce quarantine pests to farmlands, forests and other areas.

ISPM No. 41 identifies and categorizes the pest risk associated with the international movement of used VME in agriculture, forestry, horticulture, earthmoving, surface mining, waste management and military operations. It identifies appropriate phytosanitary measures that may apply to used VME, comprising cleaning and treatment; prevention from contamination; requirements for facilities and waste disposal; and verification procedures (see section 3.13).

4.15 POST-ENTRY QUARANTINE

Design and operation of post-entry quarantine stations for plants (ISPM No. 34, 2021) (IPPC Secretariat, 2016g)

ISPM No. 34 describes general guidelines for the design and operation of post-entry quarantine stations for holding imported consignments of plants, mainly plants for planting, in confinement to verify whether they are infested with quarantine pests.

4.16 AUTHORIZING ENTITIES TO PERFORM PHYTOSANITARY ACTIONS AND AUDITING

International movement of used vehicles, machinery and equipment (ISPM No. 41, 2017) (IPPC Secretariat, 2017b)

ISPM 45 provides requirements for NPPOs if they decide to authorize entities to perform specific phytosanitary actions on their behalf. In doing so, the NPPO remains responsible for the phytosanitary actions performed on its behalf.

ISPM 47 covers audits in the phytosanitary context conducted by an NPPO in its own territory or with, and in the territory of, another NPPO. It also covers audits conducted by entities authorized by an NPPO to conduct audits on its behalf.

5 The way forward

Forest pests are a global problem and it is necessary, therefore, to look beyond national borders to develop effective solutions. Despite many improvements in phytosanitary protection, introductions of new forest pests continue because of the increase in volume and frequency of international trade and travel. Climate change is also increasing the probability of new pest establishment, as well as providing conditions that enable some species to become more serious pests in their native ranges. Foresters and scientists must increase their efforts to work together with NPPOs to take the actions necessary to prevent pest introduction and spread.

Fortunately, information-sharing between the forest sector and plant-health regulators is already helping prevent, detect and eradicate new pest outbreaks. FAO has facilitated the creation of four regional invasive species networks: (1) the Asia-Pacific Forest Invasive Species Network; (2) the Forest Invasive Species Network for Africa; (3) the Forest Invasive Species Network for Europe and Central Asia; and (4) the Near East Network on Forest Health and Invasive Species. These networks, which collectively cover approximately 100 countries, enable the exchange of information, the mobilization of resources and the raising of regional awareness, and they also connect experts, institutions and stakeholders concerned with forest invasive species. The continued expansion of these networks and connection to FAO's global invasive species network, and the use of new and emerging technologies, can assist in addressing the challenge of global forest pest control.

Good forest management practices, such as those described in this guide, can help reduce pest outbreaks and prevent pests from moving internationally via forest commodities. IPM begins with planning what to grow and where to grow it. Careful surveillance, the management of forest stands throughout the growing cycle, and good practices during harvesting, transport and storage can bring high-quality, low-pest-risk products to international markets. Understanding and meeting the phytosanitary requirements of importing countries help ensure the safe movement of forest commodities and reduce the overall cost and impacts on international trade. Existing ISPMs provide important guidance for reducing forest pest movement in international trade, and new ISPMs related to the trade of forest commodities continue to be developed in response to international needs. Fifteen new international phytosanitary standards have been adopted since 2011, when the first edition of this guide was published, including many with direct relevance to forests and the forest sector. For example, standards are now available that address the pest risk associated with the movement of plants for planting

(ISPM No. 36), seeds (ISPM No. 38), wood commodities (ISPM No. 39) and used VME (ISPM No. 41).

It is important that people working in the forest sector, including industries, continue to participate in the development of relevant phytosanitary standards through their NPPOs, especially during the country consultation stage. With their special knowledge and expertise, these stakeholders can provide valuable inputs to the development of new ISPMs and help ensure that measures are practical. Thus, working closely with NPPOs, they can promote the safer trade of forest commodities.

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Annex 1

Examples of forest pest introductions and their impacts

Agrilus planipennis, emerald ash borer

IMPACTS

Has caused the death or decline of millions of trees in Canada and the United States; predicted to ultimately kill most ash trees in forests, urban plantings and shelterbelts. In the Russian Federation, the emerald ash borer has killed most ash trees within 100 km of Moscow. The borer has also moved to eastern Ukraine, where it is spreading rapidly; forests elsewhere in Europe are vulnerable.

PATHWAYS

- Movement of plants, wood and wood products, especially fuelwood, and wood packaging material.
- Flight and wind dispersal.
- Movement of vehicles and equipment ("hitchhiking") (Selikhovkin *et al.*, 2022).

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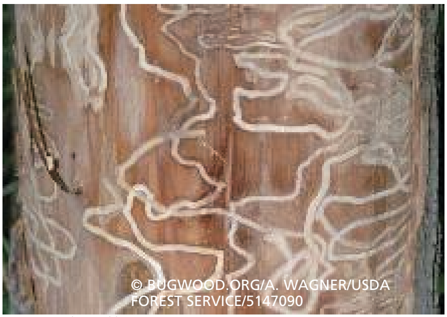
Adult emerald ash borer, Agrilus planipennis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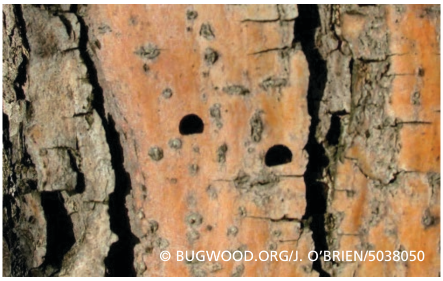
Larval galleries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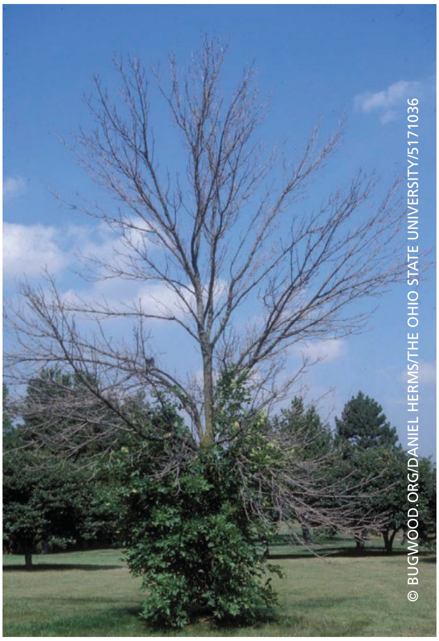
Exit holes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Infested tree exhibiting root sprouts and crown dieback

MAIN HOSTS

Fraxinus spp. (ash), *Juglans* spp. (walnut), *Pterocarya* spp. (Japanese wingnut), *Ulmus* spp. (elm).

NATIVE RANGE

China, Democratic People's Republic of Korea, Japan, Mongolia, Republic of Korea, far east of Russian Federation.

INTRODUCED RANGE

Europe: Russian Federation (Moscow, St Petersburg – close to Estonia, Finland and Latvia – and infestations in the south, close to Kazakhstan), Ukraine.

North America: Canada, United States.

SYMPTOMS AND DAMAGE

Larvae infest upper and middle trunks and lower portions of main branches, causing yellowing and thinning of foliage; dieback and death of trees normally within three years.

Anoplophora glabripennis, Asian longhorned beetle

IMPACTS

One of the world's top 100 most invasive alien species. Together with *Anoplophora chinensis*, it is predicted that, without phytosanitary measures, the Asian longhorned beetle could cause damage totalling about EUR 85 billion and a loss of 30 percent of the hardwood forest area in the European Union. In the United States, it is estimated that the damage could be greater than that caused by Dutch elm disease, chestnut blight and spongy (gypsy) moth combined. Climate change increases the risk of establishment in northern Europe.

PATHWAYS

Movement of solid wood packaging and wood, including fuelwood and wood products.

MAIN HOSTS

Acer spp. (maple), *Betula* spp. (birch), *Fraxinus* spp. (ash), *Juglans regia* (horse chestnut), *Platanus* spp. (sycamore), *Salix* spp. (willow), *Populus* spp. (poplar), *Ulmus* spp. (elm).

NATIVE RANGE

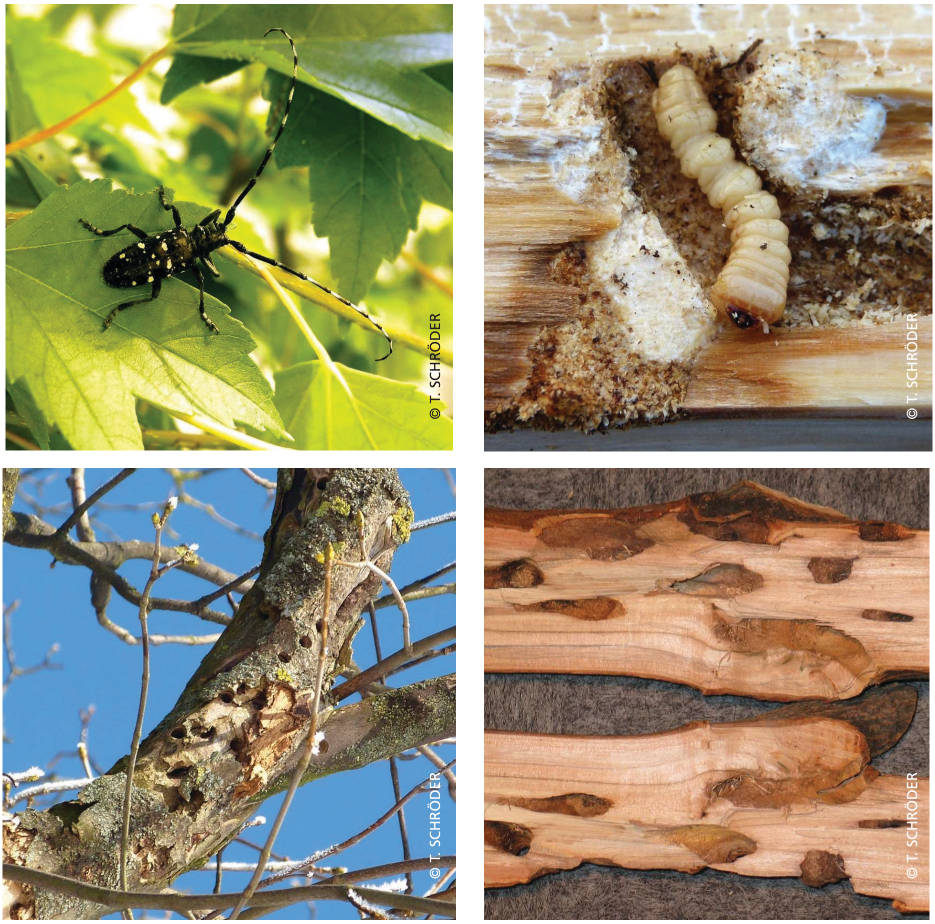
China, Republic of Korea, Taiwan Province of China.

INTRODUCED RANGE

Under eradication or already eradicated in Canada, Finland, France, Italy, Germany, Montenegro, the Kingdom of the Netherlands, United Kingdom, United States.

SYMPTOMS AND DAMAGE

Larvae feed first in the cambium layer in the upper crowns and trunks of young trees. Older larval instars feed in wood in galleries up to 3.5 cm wide. Round exit holes of beetles are 1–1.5 cm in diameter. Dieback and tree death.



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*Top row (L–R): adult male Asian longhorned beetle (*Anoplophora glabripennis*); larvae. Bottom row (L–R): exit holes; larval galleries*

Cinara cupressi sensu lato, cypress aphid

IMPACTS

Serious damage to forests in Africa, Europe and South America. Rapidly spread through Africa after accidental introduction into Malawi in 1986. By 1990, the total cost of tree loss was estimated at USD 44 million, and the cost of reduced growth in surviving trees was estimated at USD 14.6 million per year. In Kenya, it was estimated that the cypress aphid could kill up to 50 percent of all cypress trees over a 30-year harvest cycle.

PATHWAYS

Movement of nursery stock; flight and wind dispersal.

MAIN HOSTS

Cupressus spp. (cypress), *Juniperus* spp. (juniper).

NATIVE RANGE

Europe and Near East: from eastern Greece to the Islamic Republic of Iran. North America: Canada, United States.

INTRODUCED RANGE

Africa: Burundi, Democratic Republic of the Congo, Ethiopia, Kenya, Libya, Malawi, Mauritius, Morocco, Rwanda, South Africa, Uganda, United Republic of Tanzania, Zimbabwe.

Asia and the Pacific: India.

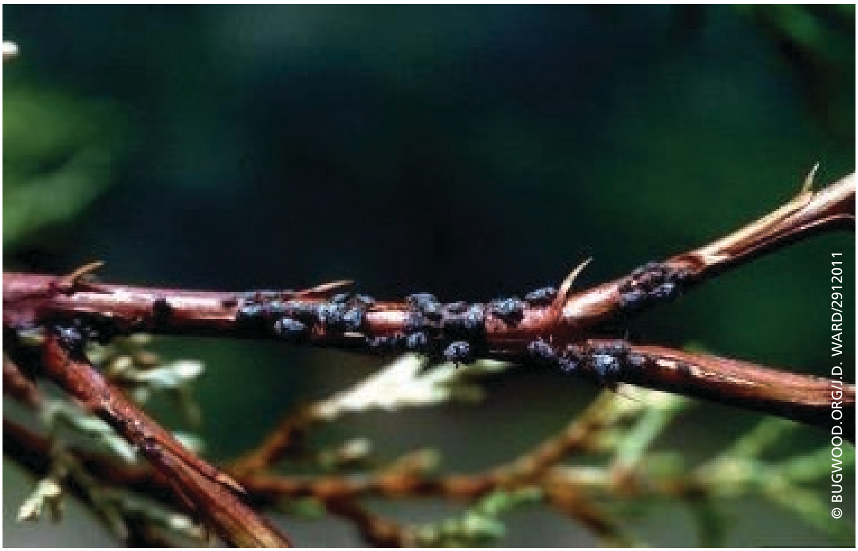
Europe: Belgium, Bulgaria, France, Germany, Greece, Italy, the Kingdom of the Netherlands, Poland, Portugal, Slovakia, Spain, United Kingdom.

Latin America and the Caribbean: Argentina, Brazil, Chile, Colombia.

Near East: Israel, Jordan, Syrian Arab Republic, Türkiye, Yemen.

SYMPTOMS AND DAMAGE

Sap-sucking on terminal growth of young and old trees retards new growth and causes stem desiccation. Progressive dieback on heavily infested trees.



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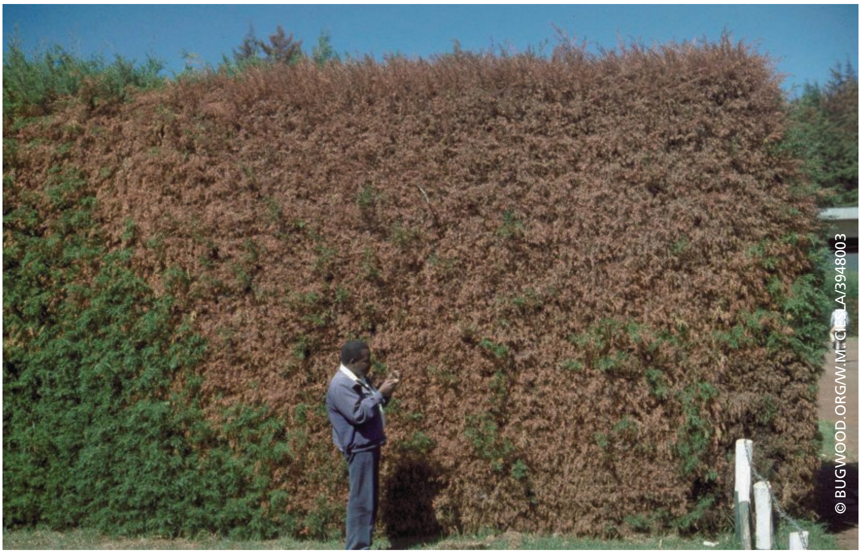
Cypress aphid, Cinara cupressi



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Damage caused by cypress aphid, Kenya

Leptocybe invasa, blue gum chalcid

IMPACTS

Major pest of young eucalypt trees and seedlings. Native to Australia, now spreading through Africa, Asia and the Pacific, Europe, Latin America and the Near East.

PATHWAYS

Movement of nursery stock; international air traffic; flight and wind dispersal.

MAIN HOSTS

Eucalyptus spp. (eucalypt).

NATIVE RANGE

Australia.

INTRODUCED RANGE

Africa: Algeria, Egypt, Ethiopia, Ghana, Kenya, Madagascar, Malawi, Mauritius, Morocco, Mozambique, Reunion, Rwanda, Sierra Leone, South Africa, Tunisia, Uganda, United Republic of Tanzania, Zimbabwe.

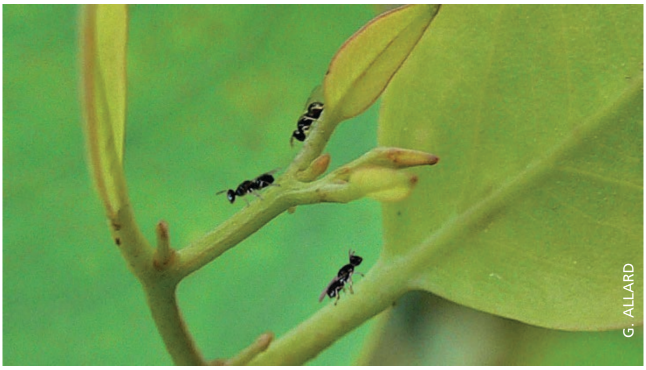
Asia and the Pacific: Cambodia, China, India, Lao People's Democratic Republic, Sri Lanka, Taiwan Province of China, Thailand, Viet Nam.

Europe: France, Greece, Italy, Portugal, Spain.

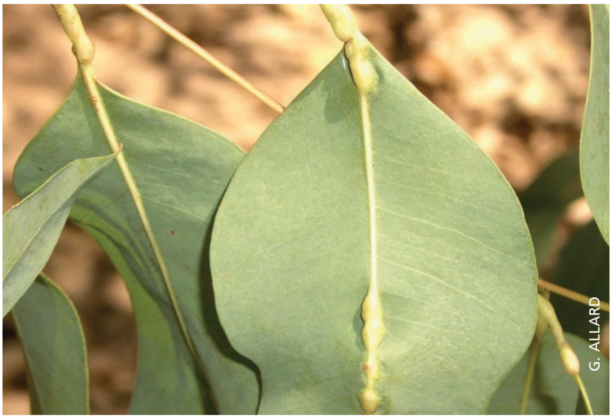
Latin America and the Caribbean: Argentina, Brazil, Chile, Mexico, Paraguay, Uruguay.

North America: United States.

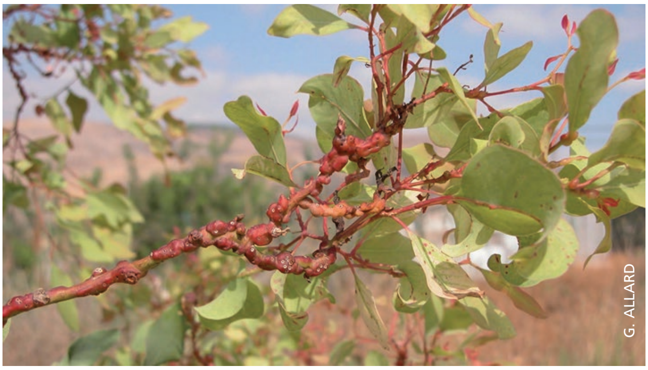
Near East: Iraq, Islamic Republic of Iran, Israel, Jordan, Lebanon, Syrian Arab Republic, Türkiye.


G. ALLARD

Ovipositing female blue-gum chalcid, Leptocybe invasa



Young galls on eucalypt branches and leaf petioles, United Republic of Tanzania



Leptocybe *damage: older galls with exit holes on eucalypt branches and leaf petioles, United Republic of Tanzania*

SYMPTOMS AND DAMAGE

Developing larvae form bump-shaped galls on leaf midribs, petioles and stems of new growth of young eucalypt trees, coppice and nursery seedlings. Severely attacked trees show leaf fall, gnarled appearance, loss of growth and vigour, stunted growth, lodging and dieback. Death can result.

Sirex noctilio, European woodwasp

IMPACTS

A threat to certain forests. Can cause considerable damage, and cost of control can be high. In New Zealand, *Pinus* tree losses reached 30 percent in the 1940s. In Tasmania, Australia, about 40 percent of *Pinus* trees died in the late 1950s; Australia-wide, 5 million trees were killed during an outbreak in 1987–1989. A serious threat to the forest industry in South Africa, where it has caused considerable losses in Eastern Cape and KwaZulu-Natal provinces. In Brazil, the potential economic impact has been estimated at USD 9 million annually (Adelino *et al*., 2021).

PATHWAYS

Flight and wind dispersal; movement of sawnwood, untreated pine logs/roundwood, and wood packaging material.

MAIN HOSTS

Pinus spp. (pine).

NATIVE RANGE

Asia, Europe, northern Africa (Algeria, Morocco, Tunisia).

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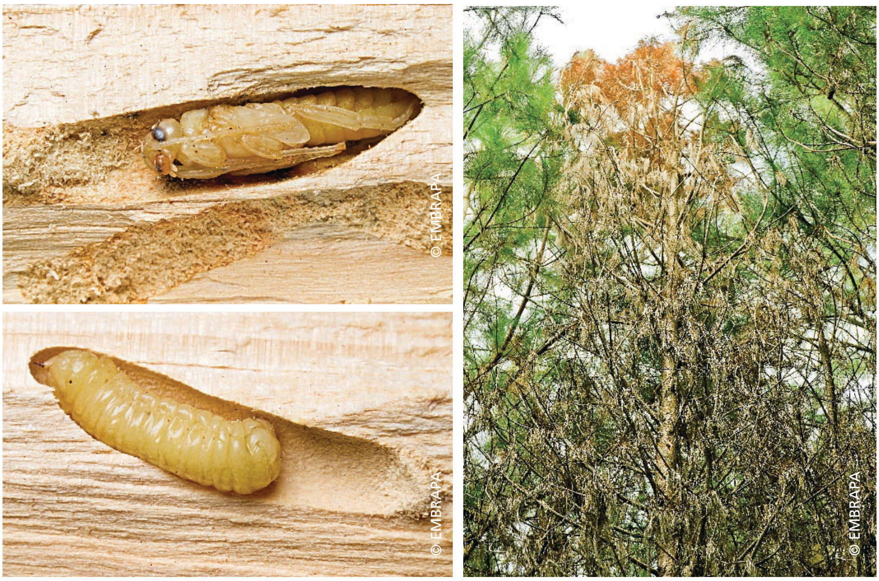
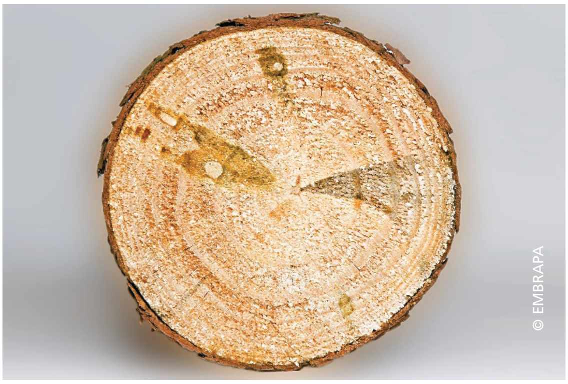
Adult female and male sirex woodwasps, Sirex noctilio



(Clockwise from bottom left) larval tunnelling, pupa at the end of a tunnel, and damage to pine trees



Cross-section of trunk showing larval tunnels filled with frass and staining caused by fungus

INTRODUCED RANGE

Africa: South Africa.

Asia and the Pacific: Australia (including Tasmania), New Zealand.

Latin America and the Caribbean: Argentina, Brazil, Chile, Uruguay.

North America: Canada, United States.

SYMPTOMS AND DAMAGE

Drills into wood to lay eggs; injects toxic mucus and a fungus (*Amylostereum areolatum*), which may result in wilting and tree death; foliage turns from green to yellow to reddish-brown. Larval tunnelling damages wood; fungus causes white rot.

Cryphonectria parasitica, chestnut blight

IMPACTS

Chestnut trees are important economically, producing durable wood (for furniture and construction) and nuts (as a cash crop and a staple food for wildlife). American chestnut (*Castanea dentata*) was one of the most abundant hardwoods in the eastern United States but is now nearly extinct because of chestnut blight – showing how a disease can fundamentally alter an entire ecosystem. Chestnut blight is causing the decline and death of chestnut trees (*Castanea sativa*) in Europe.

PATHWAYS

Movement of infected nursery stock, wood or bark; spread locally by poor harvesting techniques and by wind or blown rain.

MAIN HOSTS

Castanea spp. (chestnut), *Quercus* spp. (oak).

NATIVE RANGE

Asia.

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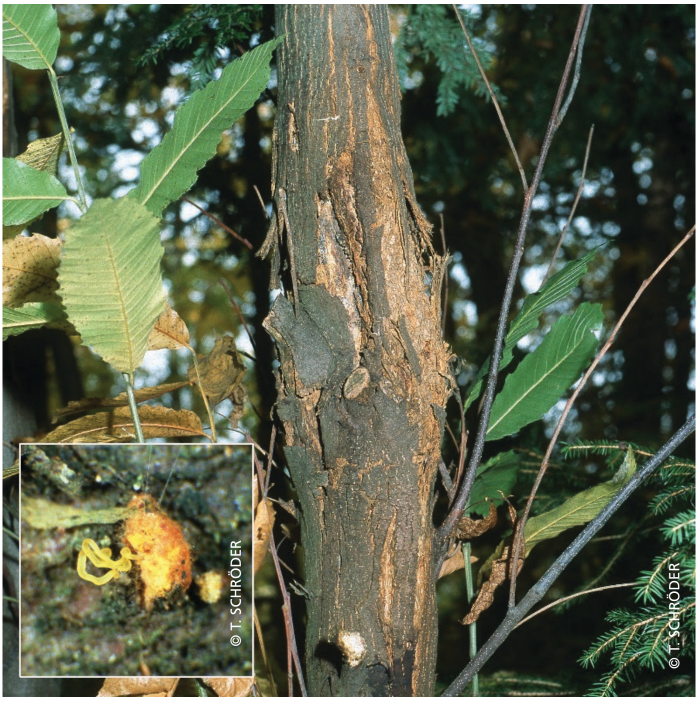
Symptoms of chestnut blight, Cryphonectria parasitica *– canker and bark necrosis*



Symptoms – stem canker. Fruiting body of Cryphonectria parasitica *(inset)*

INTRODUCED RANGE

Africa: Tunisia.

Asia and the Pacific: Azerbaijan, Australia, China, Democratic People's Republic of Korea, India, Japan, Republic of Korea, Taiwan Province of China.

Europe: Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Czechia, France, Georgia, Germany, Greece, Hungary, Italy, the Kingdom of the Netherlands, North Macedonia, Poland, Portugal, Romania, Russian Federation, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye, Ukraine, United Kingdom.

Near East: Islamic Republic of Iran, Lebanon.

North America: Canada, United States.

SYMPTOMS AND DAMAGE

Infects aboveground parts of trees only, creating cankers that expand, girdle and eventually kill tree branches and trunks.

Ophiostoma ulmi and *Ophiostoma novo-ulmi*, Dutch elm disease

IMPACTS

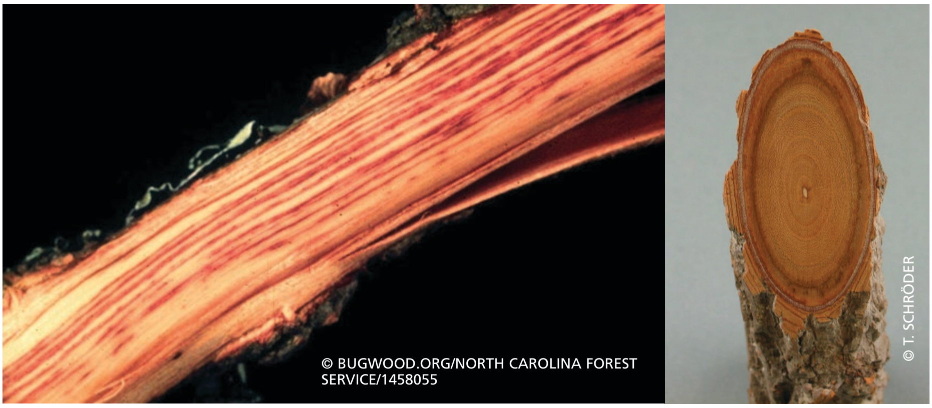
Scientists first isolated the fungus that causes this vascular wilt disease in the the Kingdom of the Netherlands (hence its name) in the 1920s. One of the most severe tree diseases in temperate regions (where elms grow). Has killed hundreds of millions of otherwise healthy mature elms in northern Asia, Europe and North America, with a major pandemic in the Northern Hemisphere from the 1920s to the 1940s. First reported in France and then spread throughout continental Europe and the United States, decimating elm populations. Disease declined in Europe but re-emerged when a second, more virulent species established in the United Kingdom, most of continental Europe, and the United States. Insect vectors are *Scolytus* spp. and *Hylurgopinus rufipes* (bark beetles).

PATHWAYS

Movement of infested or infected planting material, fuelwood and logs with bark.

MAIN HOSTS

Ulmus spp. (elm).



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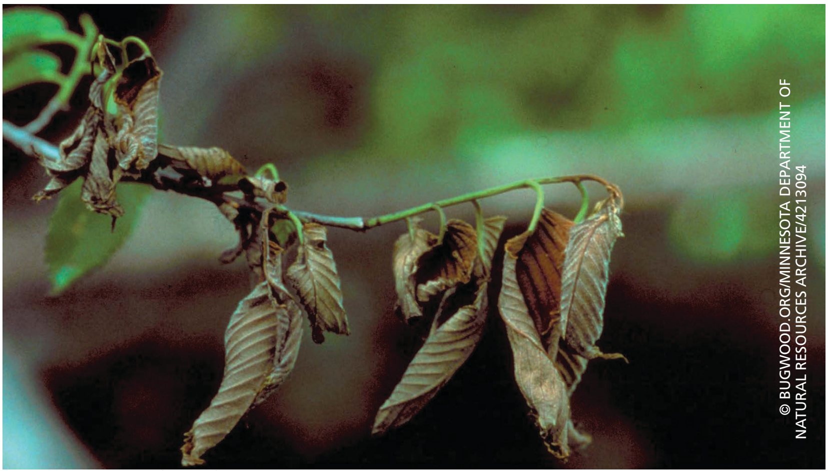
Symptoms of Dutch elm disease: (left) the streaking of vascular tissue; (right) streaking, as seen in a branch cross-section

NATIVE RANGE

Asia.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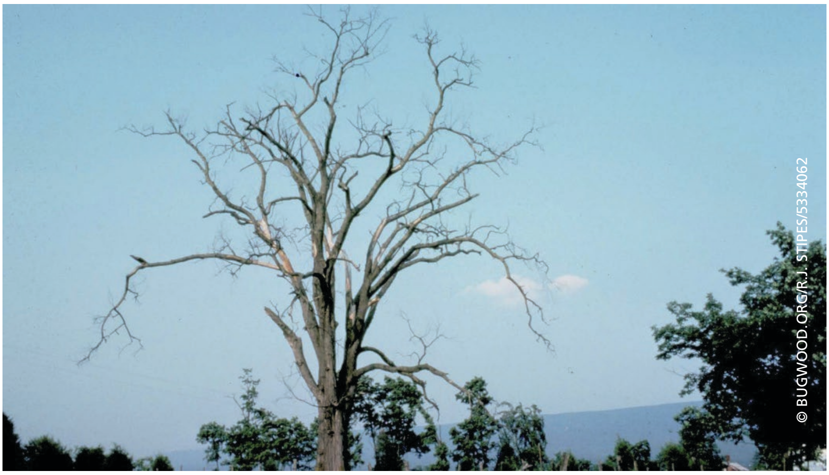
Symptoms – wilting leaves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Symptoms of Dutch elm disease on American elm, Ulmus americana

INTRODUCED RANGE

Temperate regions. Re-introduction of more virulent species from North America to Europe (mid-1960s).

SYMPTOMS AND DAMAGE

Insect vectors carry the fungus while feeding on branches; the fungus spreads via tree sap throughout the tree and can also spread from tree to tree via root grafts. Wilting, yellowing and browning of leaves; branches may be individually infected; brownish streaks of discolouration in branches and stems; symptoms may progress throughout a tree in a single season or take two or more years.

Phytophthora ramorum, sudden oak death, ramorum blight

IMPACTS

Attacks various nursery plants and trees, from where it has spread to forests. Has killed millions of oak and tanoak trees in the United States (California). Has been detected in the United Kingdom infecting Japanese larch and causing significant mortality. Inoculum remains viable in soil for years after the removal of infected trees and shrubs, thereby affecting reforestation decisions.

PATHWAYS

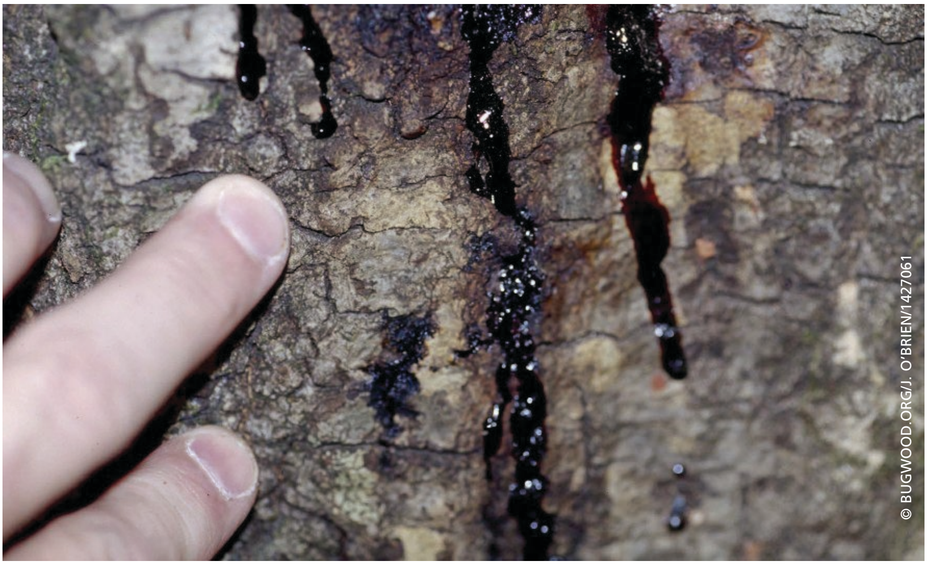
Movement of infected or contaminated plant material, growing media, nursery stock and soil on vehicles, machinery, footwear and animals.

MAIN HOSTS

Quercus spp. (oak), *Lithocarpus densiflorus* (tanoak), *Larix kaempeferi* (Japanese larch), *Rhododendron* spp. (rhododendron, azalea), *Umbellularia californica* (bay laurel), and many other plant species.

NATIVE RANGE

Unknown.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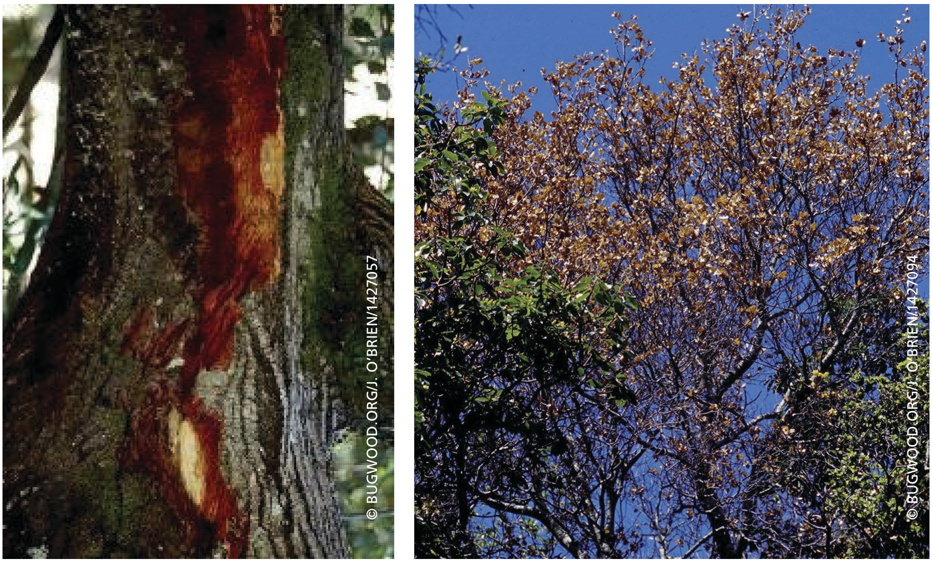
*Bleeding on coast live oak (*Quercus agrifolia*) resulting from* Phytophthora ramorum *infection*



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Symptoms of ramorum blight on Quercus agrifolia

INTRODUCED RANGE

Asia: Viet Nam.
Europe: Austria, Belgium, Croatia, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, the Kingdom of the Netherlands, Norway, Poland, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom.
Latin America and the Caribbean: Argentina.
North America: United States.

SYMPTOMS AND DAMAGE

Symptoms on oak/tanoak: stem bark lesions, bleeding basal cankers, branch cankers and crown dieback, followed by death. Symptoms on other hosts: leaf lesions, small branch cankers, and stem and branch dieback.

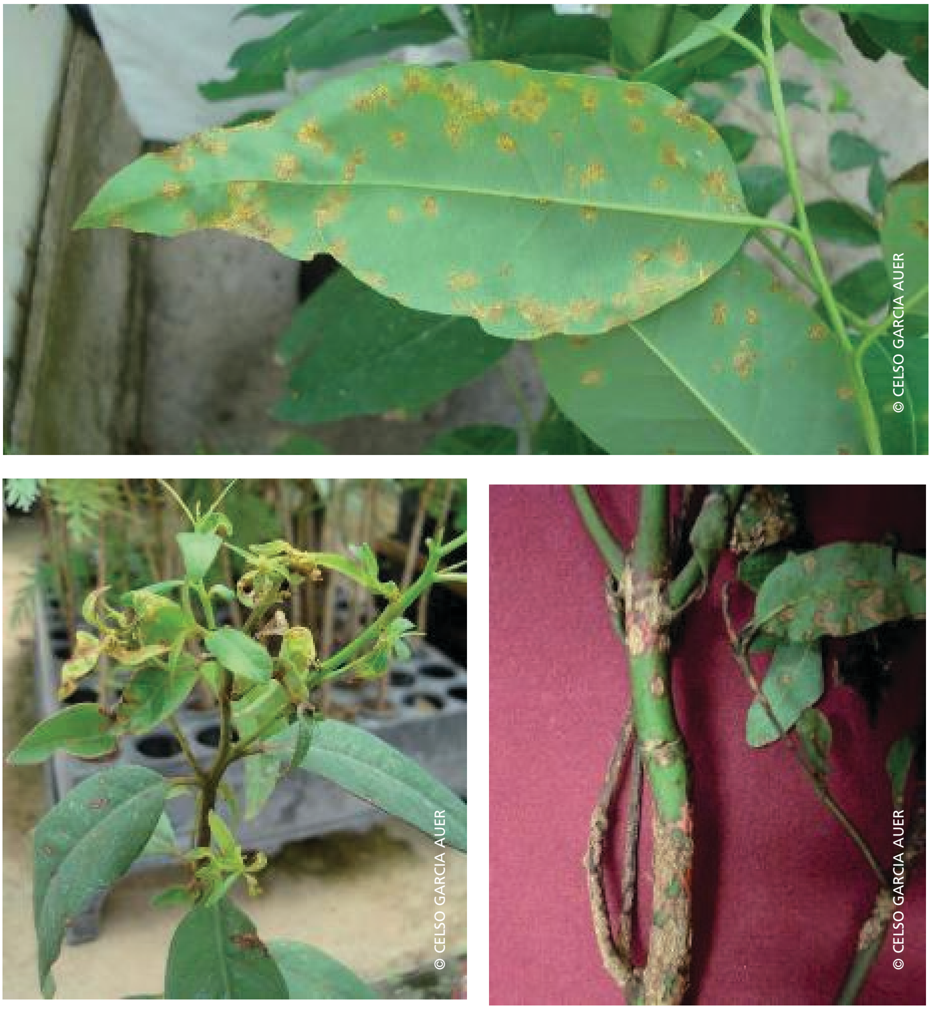
Austropuccinia psidii, eucalyptus rust

IMPACTS

Attacks many genera in the family Myrtaceae, with specific strains causing landscape-scale devastation on particular hosts. First described for guava, this pathogen causes substantial damage to eucalypt plantations in South America.

PATHWAYS

Movement of infected or contaminated plant material, cut foliage, and any items exposed to spores, which can survive for two to three months.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Symptoms of eucalyptus rust, Austropuccinia psidii

MAIN HOSTS

Eucalyptus spp. (eucalypt, eucalyptus), *Psidium* spp. (guava).

NATIVE RANGE

South and Central America.

INTRODUCED RANGE

Latin America and the Caribbean: Costa Rica, Cuba, Dominica, Dominican Republic, Guatemala, Jamaica, Mexico, Panama, Trinidad and Tobago.
North America: United States (California, Florida, Hawaii), Puerto Rico, United States Virgin Islands.
Asia and the Pacific: Australia, China, Japan, New Caledonia, New Zealand, Singapore.

SYMPTOMS AND DAMAGE

Attacks young plant tissue and can cause the deformation of leaves, the heavy defoliation of branches, dieback, stunted growth and sometimes death.

Bursaphelenchus xylophilus, pinewood nematode

IMPACTS

Threat to certain pine forests; has caused extensive tree mortality in some areas where it has been introduced; kills millions of trees annually in Japan. Insect vectors: *Monochamus* spp. (sawyer or longhorned beetles).

PATHWAYS

Flight of adult vector beetles; movement of infected and vector-infested planting material, fuelwood, timber, wood packaging material and logs.

MAIN HOSTS

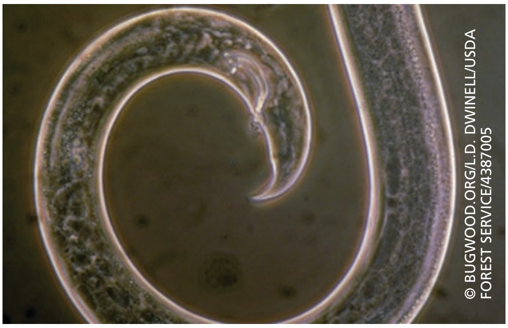
Pinus spp. (pine).

NATIVE RANGE

North America.

INTRODUCED RANGE

Asia and the Pacific: China, Japan, Republic of Korea, Taiwan Province of China. Europe: Portugal.



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Pinewood nematode, Bursaphelenchus xylophilus

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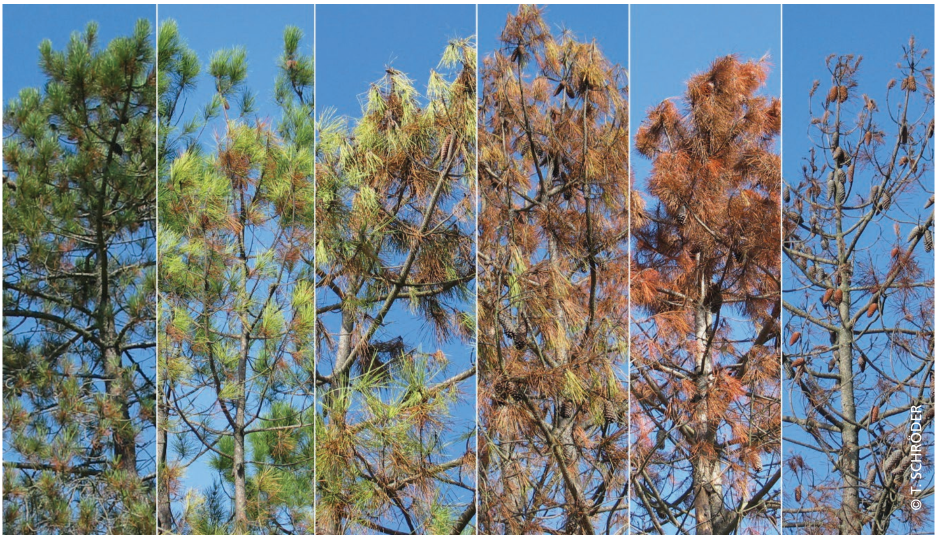
Monochamus alternatus, a vector of Bursaphelenchus xylophilus



Progression of disease impacts caused by pinewood nematode

SYMPTOMS AND DAMAGE

The nematode is deposited when adult beetles feed on or lay eggs in trees. Its presence in xylem can cause wilt and mortality; it also feeds on fungal tissues in dead trees and wood products.

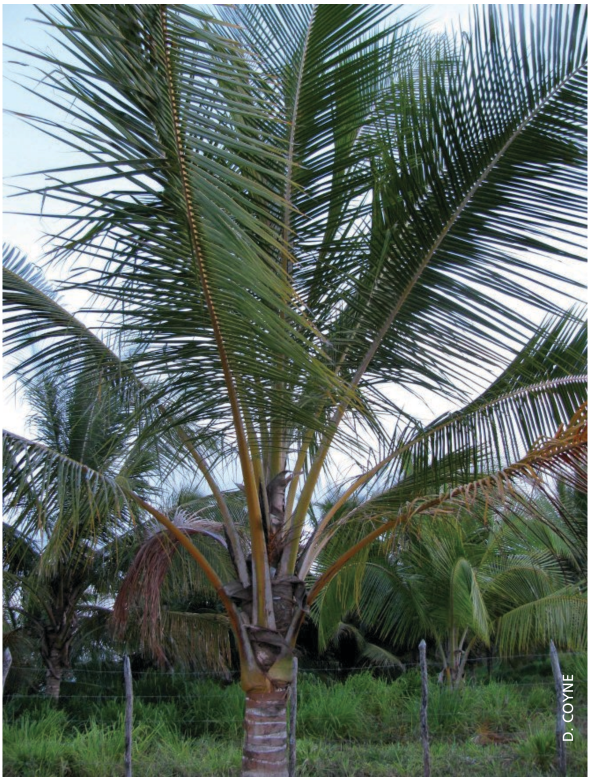
Bursaphelenchus cocophilus, red ring nematode

IMPACTS

A significant threat to coconut and other palms; young coconut palms succumb easily, but palms of various ages are affected. There is no record of palms recovering once infected, but the disease is not recognizable externally. Can cause losses of up to 80 percent – although more typically in the range of 10–15 percent – for coconut and oil palm. Insect vectors are *Rhynchophorus palmarum* and *Dynamis borassi* (palm weevils); *Metamasius hemipterus* (sugarcane weevil) is implicated in transmission.

PATHWAYS

Carried by insect vectors that feed on infected palms as larvae and transmit the nematode as adults; movement of infected and vector-infested wood products.



Damage caused by the red ring nematode, Bursaphelenchus cocophilus, *including chlorosis and browning of the leaf tips of the oldest leaves of a coconut palm, Brazil*

MAIN HOSTS

Cocos nucifera (coconut) and the oil palms *Elaeis guineensis* and *E. oleifera*.

NATIVE RANGE

Latin America and the Caribbean.

WORLD DISTRIBUTION

Belize, Bolivarian Republic of Venezuela, Brazil, Colombia, Costa Rica, Ecuador, El Salvador, French Guiana, Grenada, Guatemala, Guyana, Honduras, Mexico, Nicaragua, Panama, Peru, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago.

SYMPTOMS AND DAMAGE

The nematode is deposited when infected adult beetles feed or lay eggs in the crown of palms. Chlorosis occurs, first at the tips of older leaves, which may eventually become brown and dry. Nuts are shed prematurely; crowns of affected coconut palms often topple over (also associated with weevil damage); characteristic internal orange to brick-red ring in trunk cross-sections, but can be brownish in colour, depending on palm species and variety.

Annex 2

Glossary of terms

The definitions provided here are for the convenience of readers and are not necessarily official FAO definitions; moreover, other definitions may exist. Note that ISPMs exclusively use the definitions specified in ISPM No. 5 (IPPC Secretariat, 2023a).

Area: An officially defined country, part of a country or all or parts of several countries (ISPM No. 5, 2021).

Bark: The layer of a woody trunk, branch or root outside the cambium (ISPM No. 5, 2021).

Biological control: The use of biotic agents such as insects, nematodes, fungi and viruses for the control of weeds and other forest pests (BC Ministry of Forests and Range, 2008).

Biological control agent: A natural enemy, antagonist or competitor, or other organism, used for pest control (ISPM No. 5, 2021).

Buffer zone: An area surrounding or adjacent to an area officially delimited for phytosanitary purposes in order to minimize the probability of spread of the target pest into or out of the delimited area, and subject to phytosanitary or other control measures, if appropriate (ISPM No. 5, 2021).

Commodity: A type of plant, plant product, or other article being moved for trade or other purpose (ISPM No. 5, 2021).

Conifer: A tree belonging to the order Coniferales, usually evergreen, cone-bearing and with needles, awl or scalelike leaves such as pine, spruces, firs and tamarack, often called “softwoods” (Martin, 1996).

Consignment: A quantity of plants, plant products or other articles being moved from one country to another and covered, when required, by a single phytosanitary certificate (a consignment may be composed of one or more commodities or lots) (ISPM No. 5, 2021).

Contaminating pest: A pest that is carried by a commodity, packaging, conveyance or container, or present in a storage place and that, in the case of plants and plant products, does not infest them (ISPM No. 5, 2021).

Debarked wood: Wood that has been subjected to any process that results in the removal of bark (debarked wood is not necessarily bark-free wood) (ISPM No. 5, 2021).

Delimiting survey: A survey conducted to establish the boundaries of an area considered to be infested by or free from a pest (ISPM No. 5, 2021).

Dunnage: Wood packaging material used to secure or support a commodity but which does not remain associated with the commodity (ISPM No. 5, 2021). An example of dunnage is logs used to wedge heavy objects in a container or ship's hold to keep them from moving during shipment.

Ecosystem: A dynamic complex of plant, animal and microorganism communities and their abiotic environment interacting as a functional unit (ISPM No. 5, 2021).

A functional unit consisting of all the living organisms (plants, animals, and microbes) in a given area, and all the non-living physical and chemical factors of their environment, linked together through nutrient cycling and energy flow. An ecosystem can be of any size – a log, pond, field, forest, or the Earth's biosphere – but it always functions as a whole unit. Ecosystems are commonly described according to the major type of vegetation (e.g. forest, old-growth or range ecosystem) (BC Ministry of Forests and Range, 2008).

Emergency action: A prompt phytosanitary action undertaken in a new or unexpected phytosanitary situation (ISPM No. 5, 2021).

Entry (of a pest): Movement of a pest into an area where it is not yet present, or is present but not widely distributed and being officially controlled (ISPM No. 5, 2021).

Eradication: Application of phytosanitary measures to eliminate a pest from an area (ISPM No. 5, 2021).

Establishment (of a pest): Perpetuation, for the foreseeable future, of a pest within an area after entry (ISPM No. 5, 2021).

Fibreboard: A panel manufactured from fibres of wood or other lignocellulosic materials with the primary bond deriving from the felting of the fibres and their inherent adhesive properties (although bonding materials and/or additives may be added in the manufacturing process). It includes fibreboard panels that are flat-pressed and moulded fibreboard products. It is an aggregate comprising hardboard, medium-density fibreboard and other fibreboard (UNECE *et al*., 2008).

Field: A plot of land with defined boundaries within a place of production on which a commodity is grown (ISPM No. 5, 2021).

Forest: Land spanning more than 0.5 hectares with trees higher than 5 metres and a canopy cover of more than 10 percent, or trees able to reach these thresholds *in situ*. It does not include land that is predominantly under agricultural or urban land use (FAO, 2007).

Forestry: The science of establishing, cultivating and managing forests and their attendant resources (Hubbard, Latt and Long, 1998).

Fuelwood: Woodfuel where the original composition of the wood is preserved (FAO, 2004).

Fumigation: Treatment with a chemical agent that reaches the commodity wholly or primarily in a gaseous state (ISPM No. 5, 2021).

Genetic diversity: The genetic variability within a population or a species. It is one aspect of biological diversity. Genetic diversity can be assessed at three levels: (a) diversity within breeding populations; (b) diversity between breeding populations; and (c) diversity within a species (FAO/IUFRO, 2002).

Genotype: The genetic constitution of an organism as distinguished from its appearance or phenotype (FAO/IUFRO, 2002).

Habitat: Part of an ecosystem with conditions in which an organism is naturally present or can establish (ISPM No. 5, 2021).

Handicraft: A class of articles derived from or made of natural components of wood, twigs and vines, including bamboo poles and garden stakes.

Hitch-hiker pest: See *Contaminating pest*

Host range: Species capable, under natural conditions, of sustaining a specific pest or other organism (ISPM No. 5, 2021).

Import permit: An official document authorizing importation of a commodity in accordance with specified phytosanitary import requirements (ISPM No. 5, 2021).

Incidence (of a pest): Proportion or number of units in which a pest is present in a sample, consignment, field or other defined population (ISPM No. 5, 2021).

Infestation (of a commodity): Presence in a commodity of a living pest of the plant or plant product concerned. Infestation includes infection (ISPM No. 5, 2021).

Inoculum: Microbial spores or parts (such as mycelium) (FAO, 2001).

Inspection: Official visual examination of plants, plant products or other regulated articles to determine if pests are present or to determine compliance with phytosanitary regulations (ISPM No. 5, 2021).

Introduced species: A species, subspecies or lower taxon occurring outside its natural range (past or present) and dispersal potential (i.e. outside the range it occupies naturally or could occupy without direct or indirect introduction or care by humans) (FAO, 2007). This definition refers to trees.

Introduction: The entry of a pest resulting in its establishment (ISPM No. 5, 2021).

Invasive species: Species that are non-native to a particular ecosystem and whose introduction and spread cause, or are likely to cause, sociocultural, economic or environmental harm or harm to human health (FAO, 2007).

Log: Any section of the bole, or of the thicker branches, of a felled tree after delimbing and bucking (Dykstra and Heinrich, 1996). Synonymous with *roundwood*.

Lot: A number of units of a single commodity, identifiable by its homogeneity of composition, origin etc., forming part of a consignment (ISPM No. 5, 2021).

Medium-density fibreboard: Dry-process fibreboard. When density exceeds 0.8 g/cm^3, it may also be referred to as high-density fibreboard (UNECE *et al*., 2008).

Monitoring: An official ongoing process to verify phytosanitary situations (ISPM No. 5, 2021).

Monoculture: In general, even-aged, single-species forest crops (BC Ministry of Forests and Range, 2008).

National plant protection organization: Official service established by a government to discharge the functions specified by the IPPC (ISPM No. 5, 2021).

Native species: A species, subspecies or lower taxon, occurring within its natural range (past or present) and dispersal potential (i.e. within the range it occupies naturally or could occupy without direct or indirect introduction or care by humans) (IUCN, 2000). Antonym: non-native or exotic (FAO, 1994).

Natural enemy: An organism which lives at the expense of another organism in its area of origin and which may help to limit the population of that organism. This includes parasitoids, parasites, predators, phytophagous organisms and pathogens (ISPM No. 5, 2021).

Naturally regenerated forest: Forest predominantly composed of trees established through natural regeneration (FAO, 2007).

Non-wood forest products: Goods derived from forests that are tangible and physical objects of biological origin other than wood. Generally includes non-wood plant and animal products collected from areas defined as forest. Specifically includes the following regardless of whether from natural forests or plantations: gum arabic, rubber/latex and resin; and Christmas trees, cork, bamboo and rattan. Generally excludes products collected in tree stands in agricultural production systems, such as fruit tree plantations, oil palm plantations and agroforestry systems when crops are grown under tree cover. Specifically excludes the following: woody raw materials and products, such as chips, charcoal, fuelwood and wood used for tools, household equipment and carvings; grazing in the forest; and fish and shellfish (FAO, 2007).

Oriented strandboard: A structural board in which layers of narrow wafers are layered alternately at right angles in order to give the board greater elastomechanical properties. The wafers, which resemble small pieces of veneer, are coated with e.g. waterproof phenolic resin glue, interleaved together in mats and then bonded together under heat and pressure. The resulting product is a solid, uniform building panel having high strength and water resistance (UNECE *et al*., 2008).

Orthodox seeds: Seeds that can be dried to low moisture content and stored at low temperatures without damage to increase seed longevity (FAO, 2022).

Outbreak: A recently detected pest population, including an incursion, or a sudden significant increase of an established pest population in an area (ISPM No. 5, 2021).

Particleboard: A panel manufactured from small pieces of wood or other lignocellulosic materials (e.g. chips, flakes, splinters, strands, shreds and shives) bonded together by the use of an organic binder together with one or more of the following agents: heat, pressure, humidity, a catalyst, etc. Particleboard is an aggregate category that includes oriented strandboard, waferboard and flaxboard (UNECE *et al*., 2008).

Pathogen: Microorganism causing disease (ISPM No. 5, 2021).

Pathway: Any means that allows the entry or spread of a pest (ISPM No. 5, 2021).

Pest: Any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products. Note that, in the IPPC, "plant pest" is sometimes used for the term "pest" (ISPM No. 5, 2021). See also *quarantine pest, regulated pest, regulated non-quarantine pest*

Pest-free area: An area in which a specific pest is absent, as demonstrated by scientific evidence, and in which, where appropriate, this condition is being officially maintained (ISPM No. 5, 2021).

Pest-free place of production: Place of production in which a specific pest is absent, as demonstrated by scientific evidence, and in which, where appropriate, this condition is being officially maintained for a defined period (ISPM No. 5, 2021).

Pest-free production site: A production site in which a specific pest is absent, as demonstrated by scientific evidence, and in which, where appropriate, this condition is being officially maintained for a defined period (ISPM No. 5, 2021).

Pest risk (for quarantine pests): The probability of introduction and spread of a pest and the magnitude of the associated potential economic consequences (ISPM No. 5, 2021).

Pest risk analysis: The process of evaluating biological or other scientific and economic evidence to determine whether an organism is a pest, whether it should be regulated, and the strength of any phytosanitary measures to be taken against it (ISPM No. 5, 2021).

Pest risk management (for quarantine pests): Evaluation and selection of options to reduce the risk of introduction and spread of a pest (ISPM No. 5, 2021).

Pest status (in an area): Presence or absence, at the present time, of a pest in an area, including where appropriate its distribution, as officially determined using expert judgment on the basis of current and historical pest records and other information (ISPM No. 5, 2021).

Phytosanitary certificate: An official paper document or its official electronic equivalent, consistent with the model certificates of the IPPC, attesting that a consignment meets phytosanitary import requirements (ISPM No. 5, 2021).

Phytosanitary certification: Use of phytosanitary procedures leading to the issue of a phytosanitary certificate (ISPM No. 5, 2021).

Phytosanitary import requirements: Specific phytosanitary measures established by an importing country concerning consignments moving into that country (ISPM No. 5, 2021).

Phytosanitary measure (agreed interpretation): Any legislation, regulation or official procedure having the purpose to prevent the introduction or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests (ISPM No. 5, 2021).

Phytosanitary security (of a consignment): Maintenance of the integrity of a consignment and prevention of its infestation and contamination by regulated pests, through the application of appropriate phytosanitary measures (ISPM No. 5, 2021).

Plant products: Unmanufactured material of plant origin (including grain) and those manufactured products that, by their nature or that of their processing, may create a risk for the introduction and spread of pests (ISPM No. 5, 2021).

Planted forest: Forest predominantly composed of trees established through planting and/or deliberate seeding (FAO, 2007).

Plants: Living plants and parts thereof, including seeds and germplasm (ISPM No. 5, 2021).

Plants for planting: Plants intended to remain planted, to be planted or replanted (ISPM No. 5, 2021).

Plywood: A panel consisting of an assembly of veneer sheets bonded together with the direction of the grain in alternate plies generally at right angles. The veneer sheets are usually placed symmetrically on both sides of a central ply or core that may itself be made from a veneer sheet or another material (UNECE *et al.*, 2008).

Provenance: The original geographic source of seed, pollen or propagules. In forestry literature, the term is usually considered synonymous with "geographic origin" and preferred to "origin" (FAO/IUFRO, 2002).

Pulp: Commodity class of soft moist mass of wood fibre used in the manufacture of paper. Pulp is made up by reducing wood chips to fibres, either by grinding them up or by chemical means, and then turning the fibres into slurry (Evans, 2000).

Quarantine pest: A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled (ISPM No. 5, 2021).

Recalcitrant seeds: Seeds that are not desiccation-tolerant; they do not dry during the later stages of development and are shed at water contents in the range of 0.3–4.0 grams per gram. The loss of water rapidly results in decreased vigour and viability, and seed death at relatively high water contents. Recalcitrant species belong mostly to trees and shrubs; common examples of plants that produce recalcitrant seeds are avocado, cacao, coconut, mango, papaya and walnut (FAO, 2018).

Regional plant protection organization: An intergovernmental organization with the functions laid down in Article IX of the IPPC (ISPM No. 5, 2021).

Regulated area: An area into which, within which or from which plants, plant products and other regulated articles are subjected to phytosanitary measures (ISPM No. 5, 2021).

Regulated article: Any plant, plant product, storage place, packaging, conveyance, container, soil and any other organism, object or material capable of harbouring or spreading pests, deemed to require phytosanitary measures, particularly where international transportation is involved (ISPM No. 5, 2021).

Regulated non-quarantine pest: A non-quarantine pest whose presence in plants for planting affects the intended use of those plants with an economically unacceptable impact and which is therefore regulated within the territory of the importing contracting party (ISPM No. 5, 2021).

Regulated pest: A quarantine pest or a regulated non-quarantine pest (ISPM No. 5, 2021).

Roundwood: Wood not sawn longitudinally, carrying its natural rounded surface, with or without bark (ISPM No. 5, 2021). Synonymous with *log*.

Sawnwood: Wood sawn longitudinally, with or without its natural rounded surface with or without bark (ISPM No. 5, 2021). It includes planks, beams, joists, boards, rafters, scantlings, laths, boxboards, sleepers and lumber, etc., in the following forms: unplaned, planed, grooved, tongued, fingerjointed, chamfered, rabbeted, V-jointed, beaded, etc. (FAO, 2005).

Seeds (as a commodity): Seeds (in the botanical sense) for planting (ISPM No. 5, 2021).

Silviculture: The art, science and practice of establishing, tending and reproducing forest stands of desired characteristics. It is based on knowledge of species characteristics and environmental requirements (North Carolina State University, 2003).

Species: A population or series of populations of organisms capable of interbreeding freely with each other but not with members of other species (FAO/IUFRO, 2002). See also *introduced species, native species*

Spread (of a pest): Expansion of the geographical distribution of a pest within an area (ISPM No. 5, 2021).

Surveillance: An official process which collects and records data on pest presence or absence by survey, monitoring or other procedures (ISPM No. 5, 2021).

Survey (of pests): An official procedure conducted over a defined period of time to determine the presence or absence of pests, or the boundaries or characteristics of a pest population, in an area, place of production or production site (ISPM No. 5, 2021).

Systems approach: A pest risk management option that integrates different measures, at least two of which act independently, with cumulative effect (ISPM No. 5, 2021).

Technically justified: Justified on the basis of conclusions reached by using an appropriate pest risk analysis or, where applicable, another comparable examination and evaluation of available scientific information (ISPM No. 5, 2021).

Timber: Trees suitable for conversion into industrial forest products. Sometimes this term is used as a synonym for industrial roundwood, and it may also be used to refer to certain large sawnwood products (e.g. bridge timbers) (Dykstra and Heinrich, 1996).

Treatment (as a phytosanitary measure): Official procedure for killing, inactivating, removing, rendering infertile or devitalizing regulated pests (ISPM No. 5, 2021).

Vector: Organisms transmitting pathogens or parasites (FAO, 2010).

Veneer sheets: Thin sheets of wood of uniform thickness, not exceeding 6 mm, rotary cut (i.e. peeled), sliced or sawn. It includes wood used for the manufacture of laminated construction material, furniture, veneer containers, etc. (UNECE *et al.*, 2008).

Visual examination: Examination using the unaided eye, lens, stereoscope or other optical microscope (ISPM No. 5, 2021).

Voucher specimen or culture: A specimen that acts as a voucher for a specific fact, hypothesis or conclusion and is typically a dried botanical collection (referred to as a “gathering” in the International Code of Botanical Nomenclature) but for some taxa (e.g. yeasts) may be a living culture (McNeill *et al.*, 2006).

Weed: A plant growing where it is not wanted. Generally used to describe plants which colonize readily and can compete for resources with a planted crop (FAO, 2001).

Wood (as a commodity): Commodities such as roundwood, sawnwood, wood chips and wood residue, with or without bark, excluding wood packaging material, processed wood material, and bamboo and rattan products (ISPM No. 5, 2021).

Woodfuel: Wood from forests, shrubs and other trees used as fuel. Woodfuels can be divided into four types of products: fuelwood, charcoal, black liquor and other (e.g. methanol, ethanol, pyrolytic gas) (FAO, 2004).

Wood-based panels: A product category that is an aggregate comprising veneer sheets, plywood, particleboard and fibreboard (UNECE *et al.*, 2008).

Wood chips: Chipped woody biomass in the form of pieces with a defined particle size produced by mechanical treatment with sharp tools such as knives. Wood chips have a subrectangular shape with a typical length of 5–50 mm and a low thickness compared to other dimensions (FAO, 2004).

Wood mulch: Bark chips, wood chips, wood shavings or sawdust intended for use as a protective or decorative ground cover (APHIS, 2010).

Wood packaging material: Wood or wood products (excluding paper products) used in supporting, protecting or carrying a commodity (includes dunnage) (ISPM No. 5, 2021).

Annex 3

List of all adopted International Standards for Phytosanitary Measures

A brief description of the adopted ISPMs is provided below; the full texts are available online[17] in Arabic, Chinese, English, French, Russian and Spanish. This list was current as of January 2024.

ISPM No. 1 (2006) – ***Phytosanitary principles for the protection of plants and the application of phytosanitary measures in international trade***
Describes basic phytosanitary principles related to plant protection, including those related to the application of phytosanitary measures to the international movement of people, commodities and conveyances, as well as those related to the objectives of the IPPC.

ISPM No. 2 (2007) – ***Framework for pest risk analysis***
Describes the PRA process within the scope of the IPPC and introduces the three stages of PRA – initiation, pest risk assessment and pest risk management. The standard focuses on the initiation stage. Generic issues of information gathering, documentation, risk communication, uncertainty and consistency are also considered.

ISPM No. 3 (2005) – ***Guidelines for the export, shipment, import and release of biological control agents and other beneficial organisms***
Provides guidelines for risk management related to the export, transportation, import and release of beneficial organisms. It describes the related responsibilities of contracting parties to the IPPC, NPPOs and other responsible authorities, importers and exporters. The standard considers biological control agents capable of self-replication (including parasitoids, predators, parasites, nematodes, phytophagous organisms, and pathogens such as fungi, bacteria and viruses), as well as sterile insects and other beneficial organisms (such as mycorrhizae and pollinators), and includes those packaged or formulated as commercial products. Provisions are also included for the import of non-indigenous biological control agents and other beneficial organisms for research in quarantine facilities. This standard does not include living modified organisms, issues related to the

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[17] See https://www.ippc.int./en/core-activities/standards-setting/ispms.

registration of biopesticides, or microbial agents intended for vertebrate pest control.

ISPM No. 4 (1995) – ***Requirements for the establishment of pest free areas***
Describes the requirements for the establishment and use of PFAs as a risk management option for phytosanitary certification of plants, plant products and other regulated articles exported from the PFA or to support the scientific justification for phytosanitary measures taken by an importing country for protection of an endangered PFA.

ISPM No. 5 – ***Glossary of phytosanitary terms***
Lists terms and definitions with specific meaning for phytosanitary systems worldwide. It has been developed to provide a harmonized internationally agreed vocabulary associated with the implementation of the IPPC and ISPMs and is being revised regularly.

ISPM No. 6 (2018) – ***Guidelines for surveillance***
Describes general surveillance and specific surveys and specifies the components of survey and monitoring systems for the purpose of pest detection and the supply of information for use in PRAs, the establishment of PFAs and, where appropriate, the preparation of pest lists.

ISPM No. 7 (2011) – ***Phytosanitary certification system***
Contains requirements and describes components of a phytosanitary certification system to be established by NPPOs.

ISPM No. 8 (2021) – ***Determination of pest status in an area***
Describes the content of a pest record and the use of pest records and other information in the determination of pest status in an area. Descriptions of pest status categories are provided, as well as recommendations for good reporting practices.

ISPM No. 9 (1998) – ***Guidelines for pest eradication programmes***
Describes the components of a pest eradication programme, which can lead to the establishment or re-establishment of pest absence in an area.

ISPM No. 10 (1999) – ***Requirements for the establishment of pest free places of production and pest free production sites***
Describes the requirements for the establishment and use of pest-free places of production and pest-free production sites as pest risk management options for meeting phytosanitary requirements for the import of plants, plant products and other regulated articles.

ISPM No. 11 (2013) – ***Pest risk analysis for quarantine pests including analysis***

of environmental risks and living modified organisms
Provides details for the use of PRA to determine whether pests qualify as quarantine pests and describes the processes to be used for risk assessment and selection of pest risk management options. It also includes details regarding the analysis of risks of plant pests to the environment and biodiversity, including those risks affecting uncultivated and unmanaged plants, wild flora, habitats and ecosystems contained in the PRA area. It provides guidance on evaluating the potential phytosanitary risks to plants and plant products posed by living modified organisms.

ISPM No. 12 (2011) – *Guidelines for phytosanitary certificates*
Describes principles and guidelines for the preparation and issue of phytosanitary certificates and phytosanitary certificates for re-export.

ISPM No. 13 (2001) – *Guidelines for the notification of non-compliance and emergency action*
Describes the actions to be taken by countries regarding the notification of non-compliance of a consignment with phytosanitary import requirements, including the detection of specified regulated pests. It also outlines when and how an emergency action should be taken when there is a detection of a regulated pest or an organism that may pose a potential phytosanitary threat.

ISPM No. 14 (2002) – *The use of integrated measures in a systems approach for pest risk management*
Provides guidelines for the development and evaluation of integrated measures in a systems approach as an option for pest risk management.

ISPM No. 15 (2009) – *Regulation of wood packaging material in international trade*
Describes phytosanitary measures that reduce the risk of introduction and spread of quarantine pests associated with the movement in international trade of wood packaging material made from raw wood. Wood packaging material covered by this standard includes dunnage but excludes wood packaging made from wood which does not exceed 6 mm thickness or was processed in such a way that it is free from pests (e.g. plywood).

ISPM No. 16 (2002) – *Regulated non-quarantine pests: concept and application*
Describes the concept of regulated non-quarantine pests associated with plants for planting and identifies their characteristics. The standard describes the application and the relevant elements for regulatory systems.

ISPM No. 17 (2002) – *Pest reporting*
Describes the responsibilities of and requirements for contracting parties to the IPPC in reporting the occurrence, outbreak or spread of pests in areas for which

they are responsible. It also provides guidance on reporting successful eradication of pests and establishment of PFAs.

ISPM No. 18 (2003) – ***Guidelines for the use of irradiation as a phytosanitary measure***
Provides technical guidance on the specific procedures for the application of ionizing radiation as a phytosanitary treatment for regulated pests or articles. This does not include treatments used for the production of sterile organisms for pest control; sanitary treatments (food safety and animal health); the preservation or improvement of commodity quality (e.g. shelf-life extension); or inducing mutagenesis.

ISPM No. 19 (2003) – ***Guidelines on lists of regulated pests***
Describes the procedures to develop, maintain and make available national lists of regulated pests.

ISPM No. 20 (2017) – ***Guidelines for a phytosanitary import regulatory system***
Describes the structure and operation of a phytosanitary import regulatory system and the rights, obligations and responsibilities that should be considered in establishing, operating and revising such a system.

ISPM No. 21 (2004) – ***Pest risk analysis for regulated non quarantine pests***
Provides guidelines for conducting pest risk analysis for regulated non-quarantine pests. It describes the integrated processes to be used for risk assessment and the selection of risk management options to achieve a specified pest tolerance level.

ISPM No. 22 (2005) – ***Requirements for the establishment of areas of low pest prevalence***
Describes the requirements and procedures for the establishment of areas of low pest prevalence for regulated pests in an area, and to facilitate export of a commodity, where pests are regulated by an importing country. This includes the identification, verification, maintenance and use of areas of low pest prevalence.

ISPM No. 23 (2005) – ***Guidelines for inspection***
Describes procedures for the inspection of consignments of plants, plant products and other regulated articles at import and export. It is focused on the determination of consignment compliance with phytosanitary requirements, based on visual examination, documentary checks, and identity and integrity checks.

ISPM No. 24 (2005) – ***Guidelines for the determination and recognition of equivalence of phytosanitary measures***
Describes the principles and requirements related to the determination and recognition of equivalence of phytosanitary measures. It also describes a procedure for equivalence determinations in international trade.

ISPM No. 25 (2006) – *Consignments in transit*

Describes procedures to identify, assess and manage phytosanitary risks associated with consignments of regulated articles that pass through a country without being imported, in such a manner that any phytosanitary measures applied in the country of transit are technically justified and necessary to prevent the introduction into and/or spread of pests within that country.

ISPM No. 26 (2015) – *Establishment of pest free areas for fruit flies (Tephritidae)*

Provides guidelines for the establishment of PFAs for fruit flies of economic importance and for the maintenance of their pest-free status.

ISPM No. 27 (2006) – *Diagnostic protocols for regulated pests*

Provides guidance on the structure and content of the IPPC diagnostic protocols for regulated pests. The protocols describe procedures and methods for the official diagnosis of regulated pests that are relevant for international trade. They provide at least the minimum requirements for reliable diagnosis of regulated pests. Diagnostic protocols for regulated pests will be annexed to this standard as they are adopted by the CPM.

ISPM No. 28 (2007) – *Phytosanitary treatments for regulated pests*

Describes the requirements for submission and evaluation of the efficacy data and other relevant information on a phytosanitary treatment that can be used as a phytosanitary measure for the control of regulated pests on regulated articles, primarily those moving in international trade. The adopted treatments provide the minimum requirements necessary to control a regulated pest at a stated efficacy. Phytosanitary treatments will be annexed to this standard as they are adopted by the CPM.

ISPM No. 29 (2007) – *Recognition of pest free areas and areas of low pest prevalence*

Provides guidance and describes a procedure for the bilateral recognition of PFAs and areas of low pest prevalence. It also provides some considerations regarding pest-free places of production and pest-free production sites.

ISPM No. 30 (2008 Revoked. Incorporated as Annex to ISPM 35 in 2018) – *Establishment of areas of low pest prevalence for fruit flies (Tephritidae)*

Provides guidelines for the establishment and maintenance of areas of low pest prevalence for fruit flies by an NPPO. These areas may be utilized as official pest risk management measures alone, or as part of a systems approach.

ISPM No. 31 (2008) – *Methodologies for sampling of consignments*

Provides guidance to NPPOs in selecting appropriate sampling methodologies (both based on, and not based on, statistics) for inspection or testing of consignments to verify compliance with phytosanitary requirements. It also provides guidance on the definition of an appropriate sample size. This standard does not give guidance on field sampling (for example, as required for surveys).

ISPM No. 32 (2009) – *Categorization of commodities according to their pest risk*
Provides criteria for NPPOs of importing countries on how to categorize commodities according to their pest risk when considering import requirements. This categorization should help in identifying whether further PRA is required and if phytosanitary certification is needed.

The first stage of categorization is based on whether the commodity has been processed and, if so, the method and degree of processing to which the commodity has been subject before export. The second stage of categorization of commodities is based on their intended use after import. Contaminating pests and storage pests that may become associated with the commodity after processing are not considered in this standard.

ISPM No. 33 (2010) – *Pest free potato (*Solanum *spp.) micropropagative material and minitubers for international trade*
Provides guidance on the production, maintenance and phytosanitary certification of pest-free potato (*Solanum tuberosum* and related tuber-forming species) micropropagative material and minitubers intended for international trade. It does not apply to field-grown propagative material of potato or to potatoes intended for consumption or processing.

ISPM No. 34 (2010) – *Design and operation of post-entry quarantine stations for plants*
Describes general guidelines for the design and operation of post-entry quarantine stations for holding imported consignments of plants – mainly plants for planting – in confinement in order to verify whether they are infested with quarantine pests.

ISPM No. 35 (2012) – *Systems approach for pest risk management of fruit flies (Tephritidae)*
Provides guidance on the development, implementation and verification of integrated measures in a systems approach as an option for pest risk management of fruit flies (Tephritidae) of economic importance to facilitate trade of fruit fly host products or to minimize the spread of regulated fruit flies within an area.

ISPM No. 36 (2012) – *Integrated measures for plants for planting*
Outlines the main criteria for the identification and application of integrated measures at the place of production for the production of plants for planting (excluding seeds) for international trade. It provides guidance to help identify and manage pest risks associated with plants for planting as a pathway.

ISPM No. 37 (2016) – *Determination of host status of fruit to fruit flies (Tephritidae)*

Provides guidelines for the determination of host status of fruit to fruit flies (Tephritidae) and describes three categories of host status of fruit to fruit flies. As referred to in this standard, the term fruit is used in the botanical sense and therefore includes fruit typically called vegetables (e.g. tomato and melon). This standard includes methodologies for surveillance under natural conditions and field trials under semi-natural conditions that should be used to determine the host status of undamaged fruit to fruit flies for cases where host status is uncertain. The standard does not address requirements to protect plants against the introduction and spread of fruit flies.

ISPM No. 38 (2017) – *International movement of seeds*

Provides guidance to assist NPPOs in identifying, assessing and managing the pest risk associated with the international movement of seeds (as a commodity). The standard also provides guidance on procedures to establish phytosanitary import requirements to facilitate the international movement of seeds; on inspection, sampling and testing of seeds; and on the phytosanitary certification of seeds for export and re-export.

ISPM No. 39 (2017) – *International movement of wood*

Provides guidance on the assessment of the pest risk of wood and describes phytosanitary measures that may be used to reduce the risk of introduction and spread of quarantine pests associated with the international movement of wood, particularly those that infest trees. This standard covers only raw wood commodities and material resulting from the mechanical processing of wood: roundwood and sawnwood (with or without bark); and materials resulting from the mechanical processing of wood such as wood chips, sawdust, wood wool and wood residue (all with or without bark). This standard covers wood of gymnosperms and angiosperms (i.e. dicotyledons and some monocotyledons, such as palms), but not bamboo and rattan.

ISPM No. 40 (2017) – *International movement of growing media in association with plants for planting*

Provides guidance for the assessment of the pest risk of growing media in association with plants for planting and describes phytosanitary measures to manage the pest risk of growing media associated with plants for planting in international movement.

ISPM No. 41 (2017) – *International movement of used vehicles, machinery and equipment*

Identifies and categorizes the pest risk associated with used VME used in agriculture, forestry, horticulture, earthmoving, surface mining, waste management and by the military being moved internationally and identifies appropriate phytosanitary measures.

ISPM No. 42 (2018) – ***Requirements for the use of temperature treatments as phytosanitary measures***

Provides technical guidance on the application of various temperature treatments as phytosanitary measures for regulated pests on regulated articles. This standard does not provide details on specific treatments.

ISPM No. 43 (2019) – ***Requirements for the use of fumigation as a phytosanitary measure***

Provides technical guidance for NPPOs on the application of fumigation as a phytosanitary measure, encompassing treatments with chemicals that reach the commodity in a gaseous state. This standard also provides guidance for NPPOs on the authorization of treatment providers to conduct fumigation.

ISPM No. 44 (2021) – ***Requirements for the use of modified atmosphere treatments as phytosanitary measures***

Provides technical guidance for NPPOs on the application of modified atmosphere treatments (including controlled atmosphere treatments) as phytosanitary measures, including authorization, monitoring and auditing of treatment providers.

ISPM No. 45 (2021) – ***Requirements for national plant protection organizations if authorizing entities to perform phytosanitary actions***

Provides requirements for NPPOs if they decide to authorize entities to perform specific phytosanitary actions on their behalf.

ISPM No. 46 (2022) – ***Commodity-specific standards for phytosanitary measures***

Provides guidance on the purpose, use, content, publication and review of commodity-specific standards for phytosanitary measures.

ISPM No. 47 (2022) – ***Audit in the phytosanitary context***

Covers audits in the phytosanitary context conducted by an NPPO or entities authorized by the NPPO in its own territory, or with and in the territory of another NPPO. It also covers audits conducted by entities authorized by an NPPO to conduct audits on its behalf.

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FAO FORESTRY PAPER

Guide to implementation of phytosanitary standards in forestry

Second edition

This guide, published originally in 2011 and updated in 2024, was produced by an international group of scientists, phytosanitary authorities, forest experts and industry representatives and reviewed by more than 100 specialists from 46 countries. It provides easy-to-understand information on good forest management practices and well-implemented phytosanitary standards for minimizing pest spread and facilitating safe trade. It explains how regulations established through International Standards for Phytosanitary Measures (ISPMs) and by national plant protection organizations (NPPOs) affect the import and export of forest commodities; how ISPMs can be used to prevent pest introduction and spread; and how forest-sector personnel can work with NPPOs to contribute to the development and implementation of ISPMs and national phytosanitary regulations that help reduce pest movement while minimizing constraints on trade. The guide will be of vital interest to people involved in growing, managing, harvesting, manufacturing, trading or transporting forest commodities. It will also benefit forest policymakers, planners, managers and educators worldwide.

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